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LITERATURE

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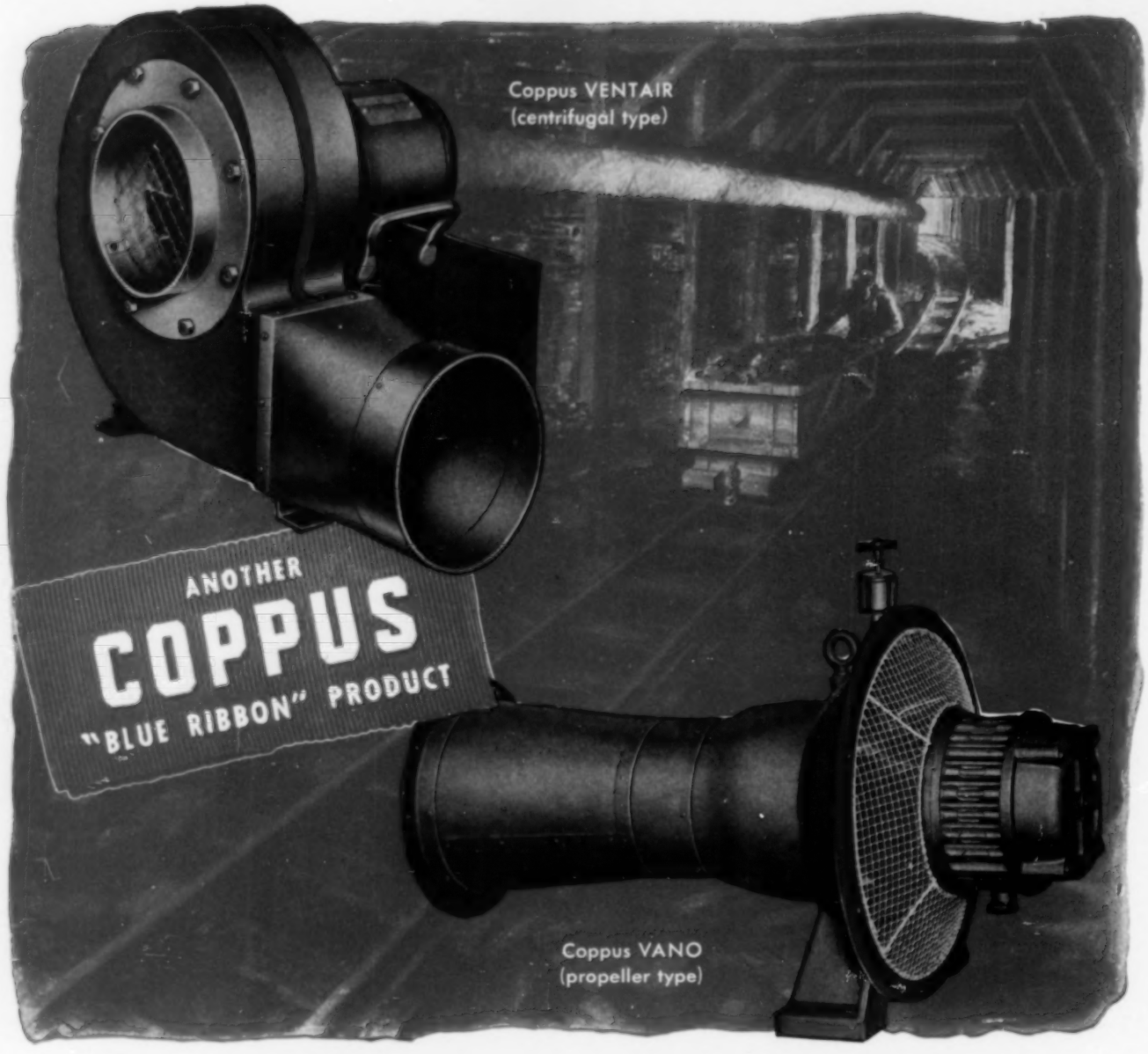
U.S. BUREAU OF RECLAMATION PHOTO

DIVER DONS GEAR AT COULEE DAM

Underwater observations to guide contractors who will repair damage from erosion

VOLUME 54 • NUMBER 1

NEW YORK • LONDON



Two Blowers . . . One Purpose: 30 to 100% More Air

Why two totally different blower types? Because the requirements of mine ventilation fall into two entirely different categories.

For high pressures, long pipe lines, use the Coppus VENTAIR (centrifugal type). For medium pressures, shorter pipe lines, the Coppus VANO (propeller type) is best. One or the other will give you more air per given power consumption than other blowers — from 30% to 100% more. Can be used as blowers or exhausters, capacities up to 90,000 CFM, with compressed air or electric motor drive.

Only Coppus makes both types. And, for quick recognition, each wears the famous "Blue Ribbon," distinguishing mark of top-quality engineering, materials and performance. This blue band is your guarantee of better mine ventilation . . . Look for it.

Representatives listed in MINING CATALOGS. Other Coppus "BLUE RIBBON" Products: steam turbines, gas burners, heat killers, air filters, blowers and exhausters for special purposes. See also THOMAS' REGISTER . . . Coppus Engineering Corporation, 541 Park Ave., Worcester 2, Mass.

COPPUS ENGINEERING CORPORATION
201 Park Avenue, Worcester 2, Mass.

Please send: Bulletin 130.....

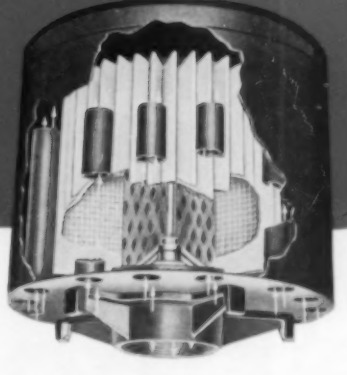
Name.....

Company.....

Address.....

IT FILTERS!

IT SILENCES!



STAYNEW MODEL DS INTAKE FILTER

Both silencing and filtering in a single compact unit! All the outstanding advantages of the original Staynew Dry-Type Radial Fin Construction: low resistance to air flow; increased efficiency with use; suitability for use on carbon ring compressors; no oil, viscous coating or charging tanks; no moving parts; inserts easily and inexpensively cleaned or replaced.

Silencing is efficiently handled without excess back pressure thru a series of cylindrical rectifying chambers of scientific diameter to length ratio.

Thousands of these well-designed, well-built Staynew Filters are already in use, saving wear on compressor and internal combustion engines, reducing intake clamor.

FOR COMPLETE DETAILS WRITE:

DOLLINGER PROTECTOMOTOR STAYNEW FILTERS

DOLLINGER CORPORATION

7 CENTRE PK., ROCHESTER 3, N. Y.

REPRESENTATIVES IN PRINCIPAL CITIES

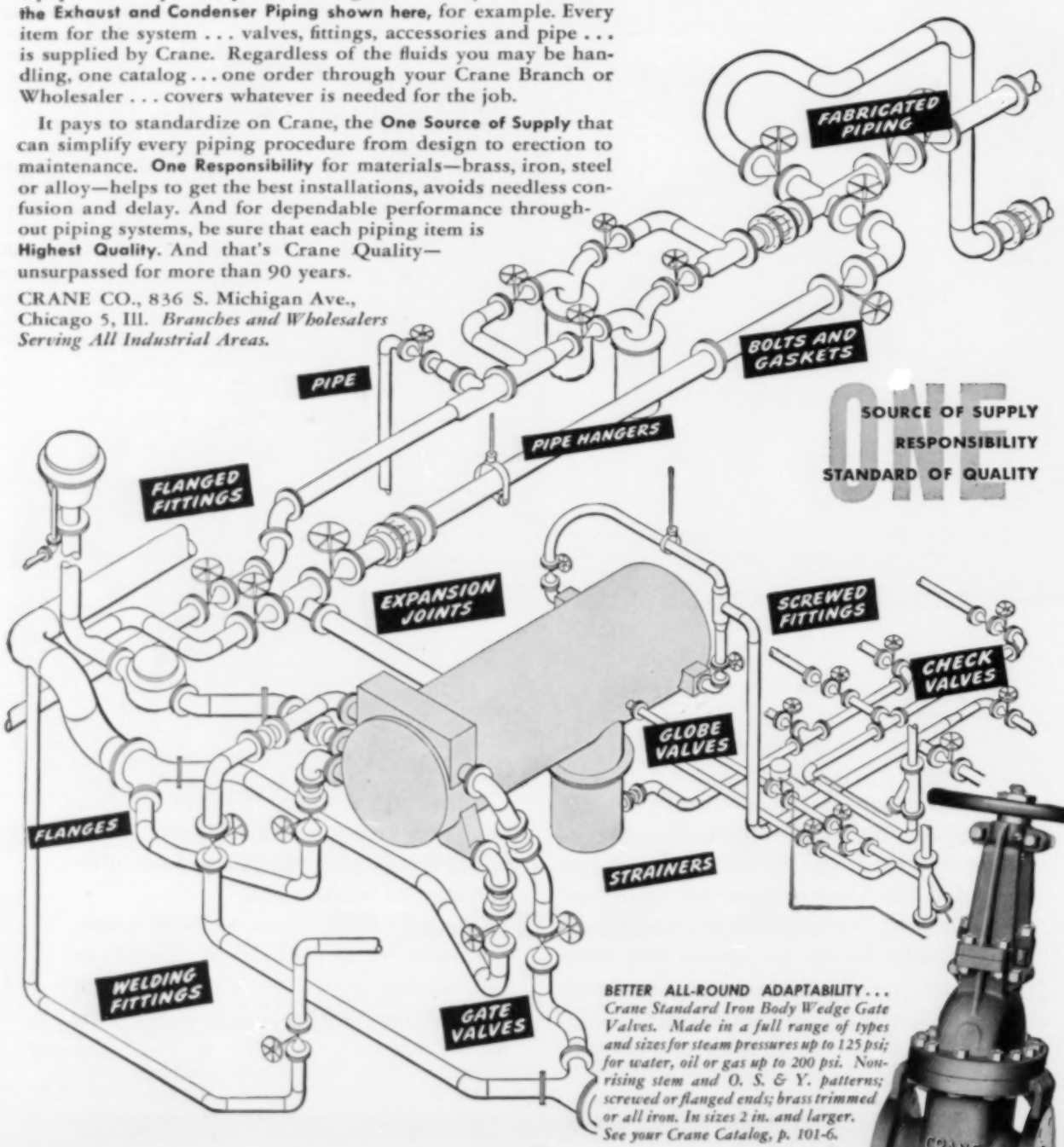
IN CANADA: McCarthy and Robinson, Toronto
Engineering Equipment Co., Montreal

Complete Piping Materials Service
. . . from one complete line

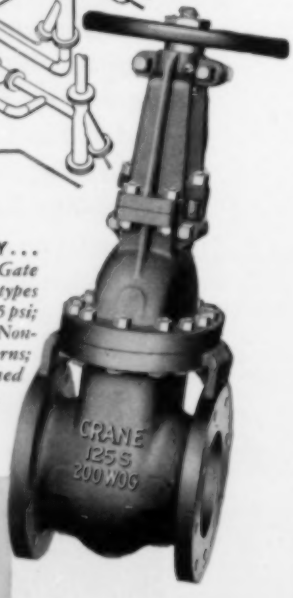
That's the Crane line—the world's most complete source of piping equipment for power, process and general utility services. **Take the Exhaust and Condenser Piping shown here,** for example. Every item for the system . . . valves, fittings, accessories and pipe . . . is supplied by Crane. Regardless of the fluids you may be handling, one catalog . . . one order through your Crane Branch or Wholesaler . . . covers whatever is needed for the job.

It pays to standardize on Crane, the **One Source of Supply** that can simplify every piping procedure from design to erection to maintenance. **One Responsibility** for materials—brass, iron, steel or alloy—helps to get the best installations, avoids needless confusion and delay. And for dependable performance throughout piping systems, be sure that each piping item is **Highest Quality.** And that's Crane Quality—unsurpassed for more than 90 years.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill. *Branches and Wholesalers Serving All Industrial Areas.*



BETTER ALL-ROUND ADAPTABILITY . . . *Crane Standard Iron Body Wedge Gate Valves. Made in a full range of types and sizes for steam pressures up to 125 psi; for water, oil or gas up to 200 psi. Non-rising stem and O. S. & Y. patterns; screwed or flanged ends; brass trimmed or all iron. In sizes 2 in. and larger. See your Crane Catalog, p. 101-6.*



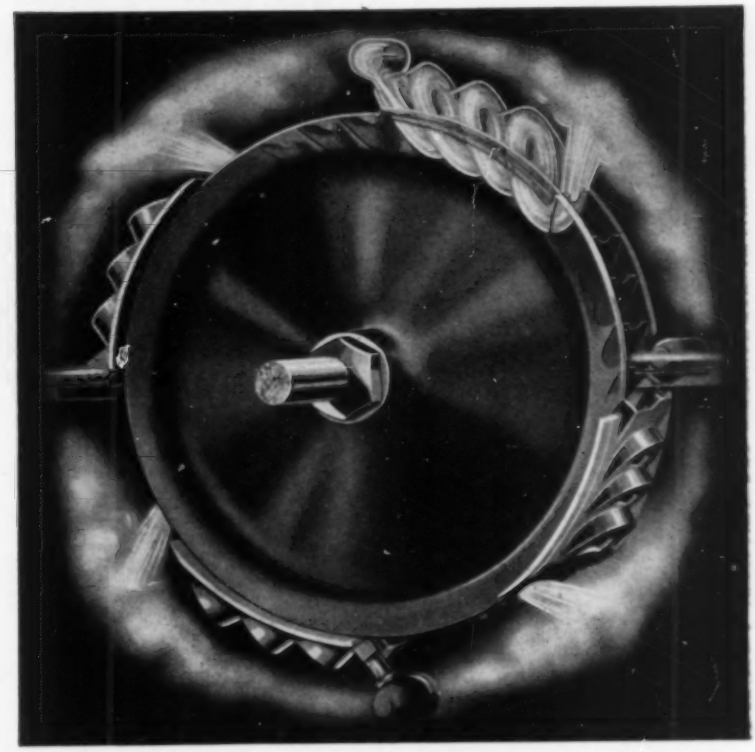
EVERYTHING FROM . . .

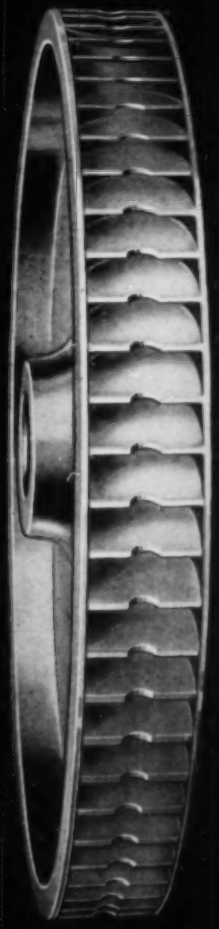
VALVES · FITTINGS
PIPE · PLUMBING
AND HEATING

CRANE

FOR EVERY PIPING SYSTEM

TERRY





BLADE PROTECTION

Made Possible by Nozzle Location

In the Terry Solid-Wheel Turbine, the steam enters the buckets from the top, not from the side of the wheel, as shown in the illustration above. This permits a one inch clearance on either side of the wheel. In addition, projecting rims on each side of the buckets prevent damage to the blades even though excessive thrust should tend to move the shaft.

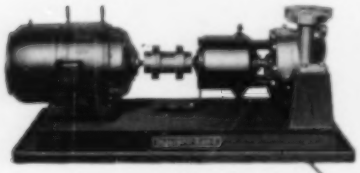
This feature and others, as important, are described in detail in Bulletin S 116 which will be sent to you on request.

T-1175

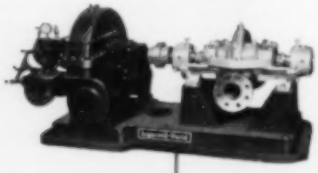
THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

You specify { **THE FLUID** (GAS OR LIQUID)
THE TEMPERATURE
AND THE PRESSURE

Vertically-split cradle mounting for pressures to 600 psi



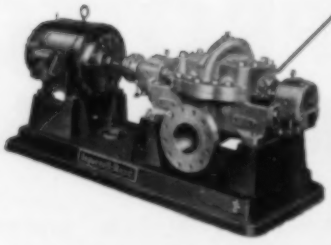
Horizontally-split, single-stage for pressures to 450 psi



Vertical, multi-stage for pressures to 1700 psi

We'll specify **THE PUMP**

Mixed flow for heads to 90 ft per stage

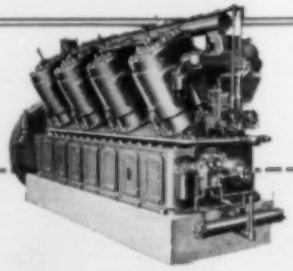


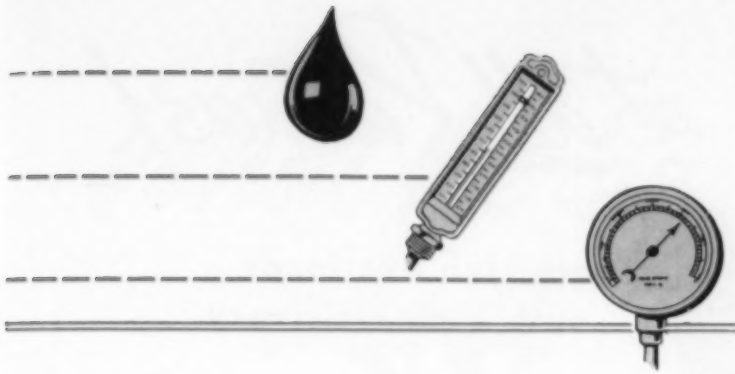
Horizontally-split, tow-stage for pressures to 500 psi

Vertically-split, two-stage for pressures to 600 psi

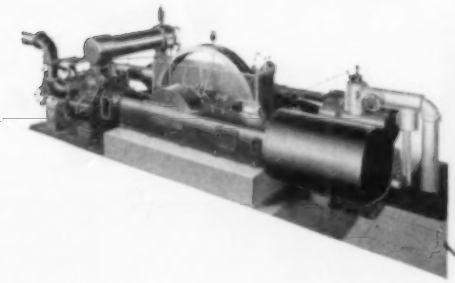
Mixed-flow vertical for pressures to 600 psi

...And **WE ALSO BUILD**

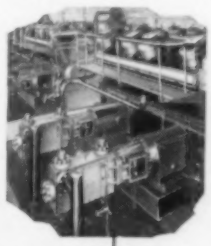




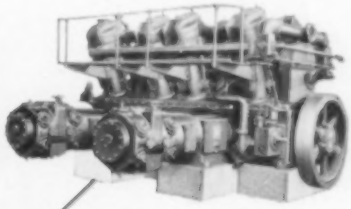
Steam-driven compressors, hp sizes to 3000



Non-lubricated cylinders for compressors of all sizes - for jobs requiring oil-free air or gas

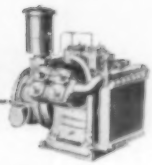


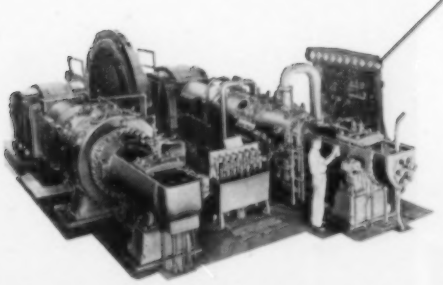
4-cycle gas-engine-driven compressors for pressures to 6000 psi 75 to 1200 hp sizes



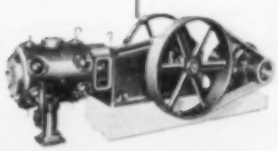
— *on the* **COMPRESSOR**

Air-cooled compressors, ½ to 90 hp

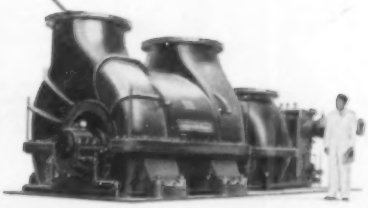




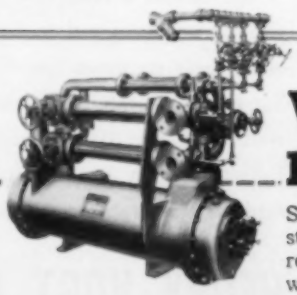
Synchronous motor-driven compressors, pressures to 15,000 psi 75 to 3000 hp sizes



Belt-driven compressors for pressures to 3000 psi, 5 to 300 hp sizes



Centrifugal Blowers for pressures from ½ to 100 psi —2 to 30,000 hp sizes

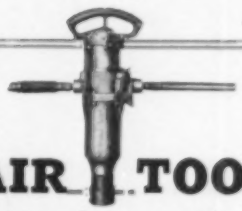


ENGINES

Gas engines—185 to 1200 hp
Diesel Engines—225 to 900 hp

VACUUM EQUIPMENT

Steam-jet ejectors—steam condensers—reciprocating vacuum pumps—water-vapor refrigeration



AIR TOOLS

A type for every need—Impact wrenches—drills—grinders—chippers—scales—tampers—diggers—etc.

Ingersoll-Rand

11 BROADWAY, NEW YORK 4, N. Y.

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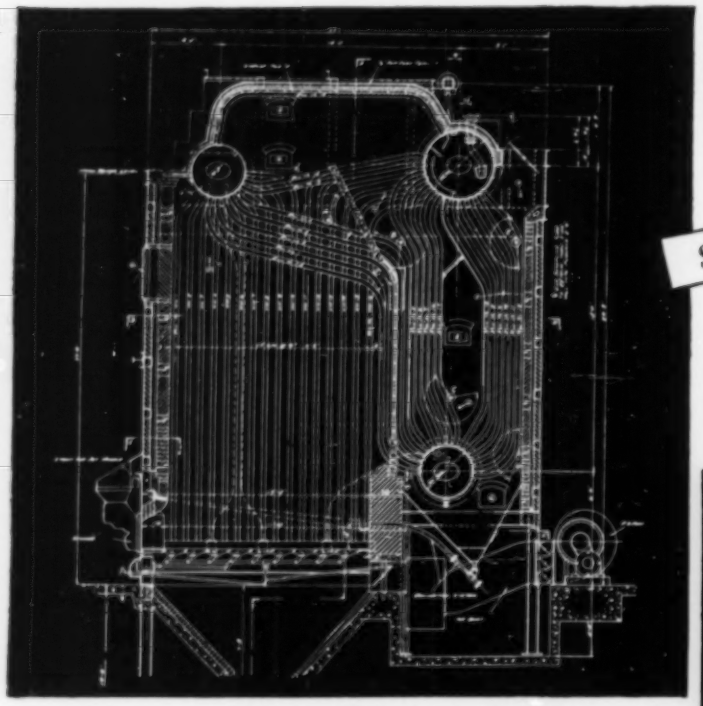
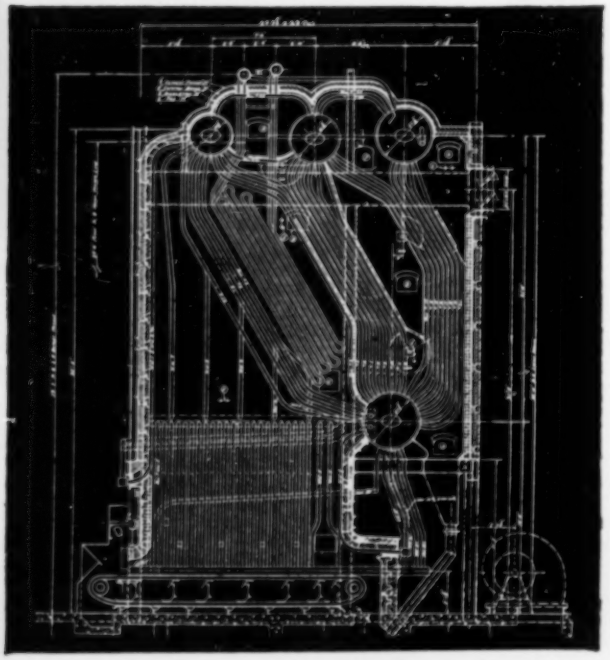
Quick Steaming at all Ratings!



Carry high overloads with high efficiency

SPECIFY **Vogt**

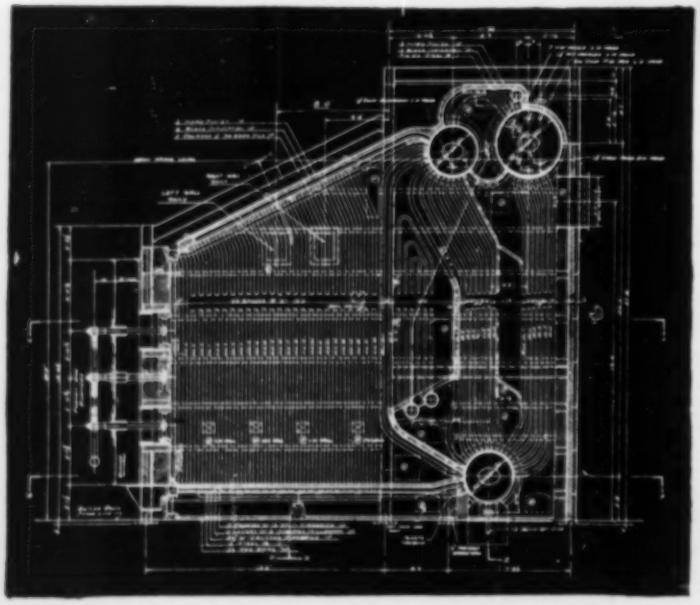
STEAM GENERATING UNITS



CLASS VL Two 27,500 pounds per hour units, installed at Brown-Forman Distillers Corporation, Louisville, Ky. Features large furnace volume in limited space, with high ratio of radiant heating surface.

CLASS LE Mt. Carmel Public Utility, Mt. Carmel, Illinois, is served by this 60,000 pounds per hour unit. Generous steam liberating surfaces and steam space permit wide fluctuations in load.

CLASS VR 70,000 pounds per hour steam generator at Humble Oil and Refining Company, Johnsue, Texas. An efficient, high-duty unit with water cooled furnace, using refinery gas fuel.



Vogt builds a complete line of bent tube steam generators, designed to burn solid, liquid, or gaseous fuels to meet specific operating conditions. Superheaters, air preheaters, economizers, water walls, and soot blowers can be readily incorporated. Bulletins with general information and showing typical installations are available upon request.

HENRY VOGT MACHINE CO.

LOUISVILLE 10, KENTUCKY

BRANCH OFFICES:
NEW YORK, PHILADELPHIA, CLEVELAND
CHICAGO, ST. LOUIS, DALLAS

What He Says about KINKING

One of the quickest ways to ruin a wire rope is to let it kink. That, says the Bethlehem engineer, is certain death for the rope. Even though your eye may detect no damage . . . it's been done. For kinking throws wires and strands out of harmonious balance; leads to spot wear and wire breakage long before the rope has lived its normal life.

Improper unreeling is a common cause of destructive kinking. Never lay the reel on its side without a turntable and attempt to lift off the rope. That's just asking for trouble. Instead, jack up the reel so that it revolves freely; then, while one man "brakes" the reel, another should slowly pull off the rope in a straight line.

Be careful, too, when handling a *coil* of rope—one not wound on a reel. Merely grabbing the rope and starting to pull will invariably produce damaging loops and kinks. To uncoil, place the end of the rope on the ground, then roll the coil like a hoop, in as straight a line as possible.

The Bethlehem field engineer will gladly give any helpful pointers on the proper way to unreel and uncoil wire rope. It's something *every* user of rope should know.

Remember, there's no charge for the services of the Bethlehem representative, no matter how much time he spends with you. It's his job to help you in selecting wire rope and getting the best service from it. Feel free to call him on any wire-rope problem.

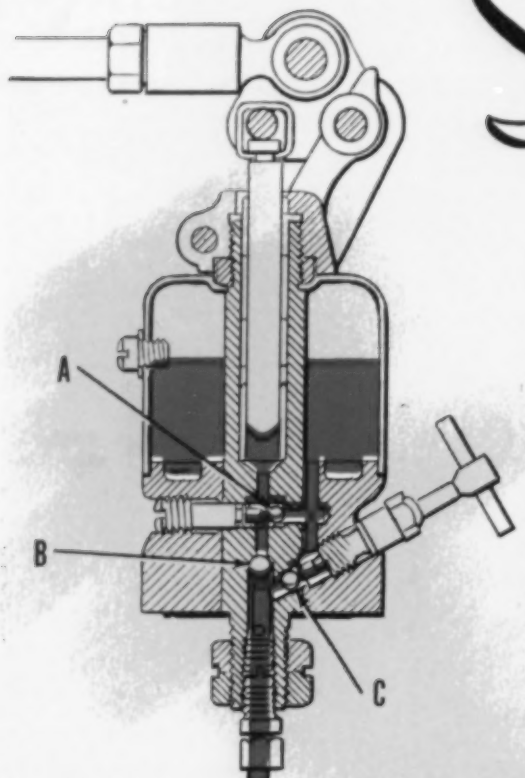
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

Export Distributor: Bethlehem Steel Export Corporation

When you think WIRE ROPE . . . think BETHLEHEM

Simple as A-B-C

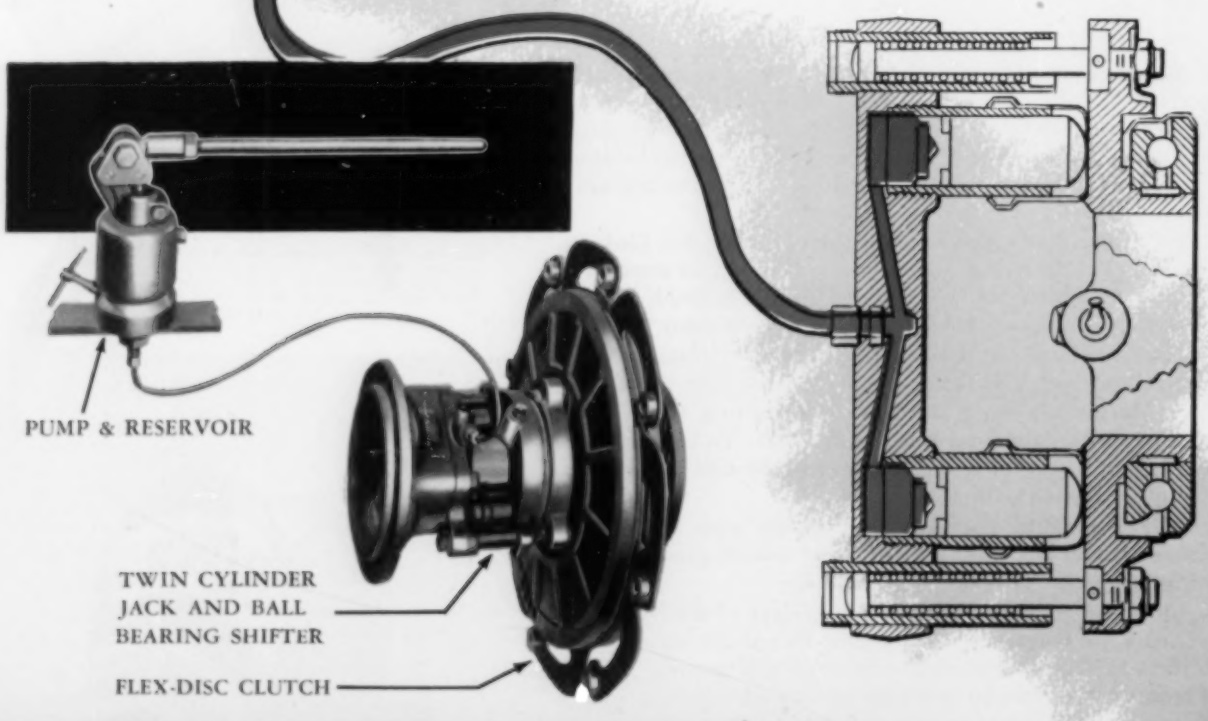


The *Hydro-Shifter* used on Ingersoll-Rand Portable Compressors equipped with *Flex-Disc* Clutches provides a simple means for operating the clutch under all temperature conditions.

When the pump handle is lifted oil flows through intake valve (A) into the pump cylinder. The following down stroke forces the oil through discharge valve (B) into the twin cylinder hydraulic jack connected by tubing to the pump. Two or three strokes of the pump handle are enough to disengage the clutch.

The clutch is just as easily engaged. When the engine is warmed up ready to drive the compressor, the operator opens release valve (C) allowing oil in the jack cylinders to return to the pump reservoir. This permits the spring loaded *Flex-Disc* Clutch to engage and drive the compressor.

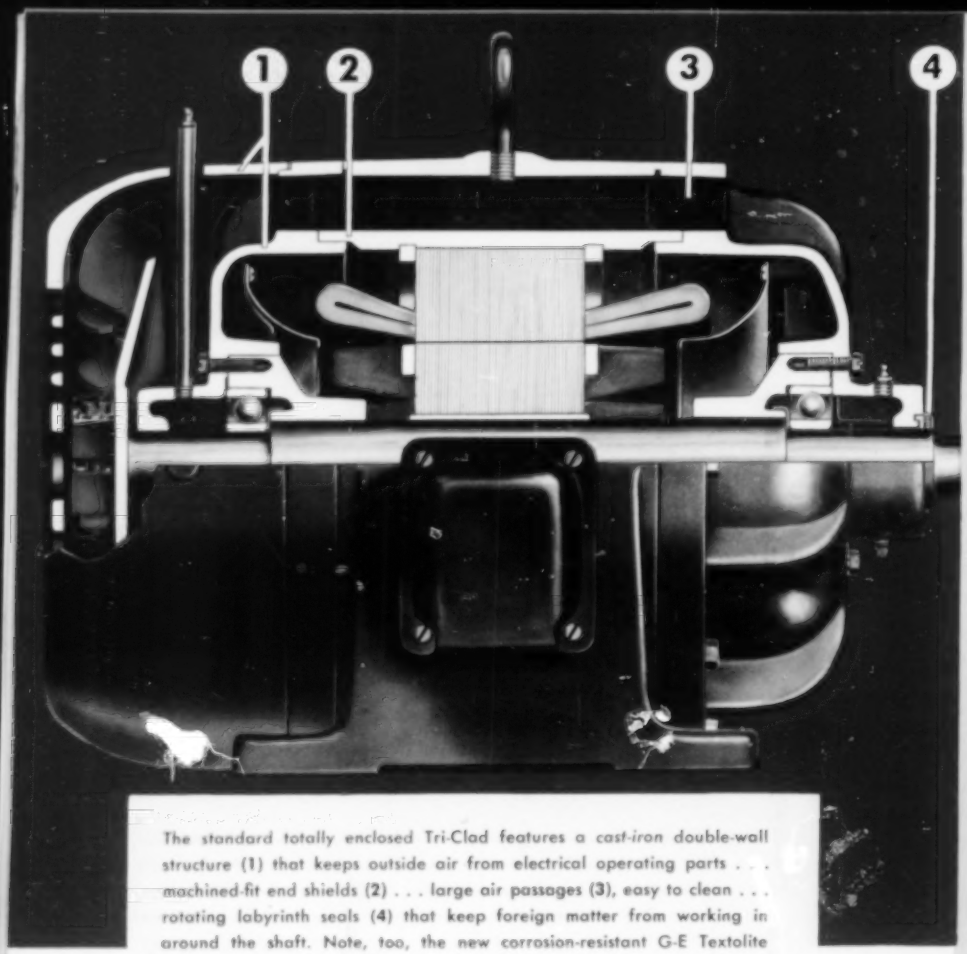
The *Flex-Disc* Clutch with hydraulic operation represents a new high in dependable starting of portable compressors under any outdoor conditions likely to be encountered.



INDUSTRIAL CLUTCH CORPORATION

Waukesha Wisconsin

YOU CAN PUT A
TRI CLAD
REG. U.S. PAT. OFF.
MOTOR ANYWHERE
GENERAL ELECTRIC
HERE'S WHY



The standard totally enclosed Tri-Clad features a *cast-iron* double-wall structure (1) that keeps outside air from electrical operating parts . . . machined-fit end shields (2) . . . large air passages (3), easy to clean . . . rotating labyrinth seals (4) that keep foreign matter from working in around the shaft. Note, too, the new corrosion-resistant G-E Textolite cooling fan is now standard on all 1- to 15 hp TEFC Tri-Clads.

You can put a TRI CLAD motor anywhere

YES SIR! The standard *Tri-Clad* open motor is a *cast-iron, dripproof* motor you can put anywhere that *any* open motor can be used—and in a lot of places where other open motors couldn't take it.

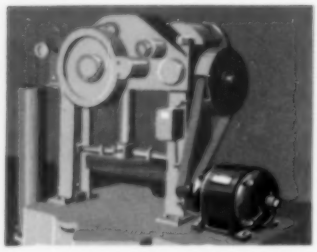
What's more, for the really dirty jobs—where air is laden with dust, or corrosive fumes—where metal chips and cutting fluids abound—the Tri-Clad totally enclosed motor gives you more protection, *inside and out*, than any other make of motor you can buy.

1,720,000 Tri-Clad motors, operating in every conceivable kind of plant, prove the far-reaching advantages of cast-iron construction . . . superior resistance to corrosion . . . rigidity that makes for permanent shaft alignment . . . inherent damping action that minimizes noise and damaging vibration. These motors prove, too, that Tri-Clad double-end ventilation simply has no equal for prolonging an open motor's useful life. Providing high-volume, relatively low-velocity cooling, this ventilating system keeps Tri-Clad motors *uniformly* "air-conditioned".

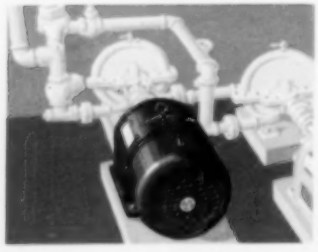
WANT MOTORS THAT CAN REALLY TAKE ABUSE? Tri-Clad motors in nearly all types and ratings are available for **IMMEDIATE SHIPMENT.** Contact your nearest G-E Office or write *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC

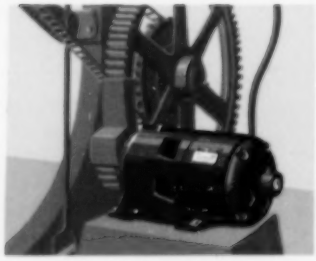
There's a Tri-Clad motor for every industrial need!



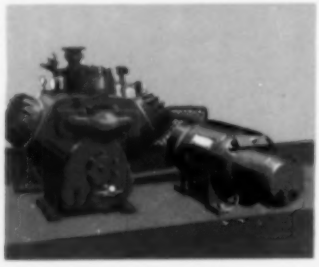
G-E open (dripproof) induction motors for constant-load, constant-speed applications. From 1 to 2000 hp.



G-E totally enclosed motors for outdoor operation, in abrasive dusts, or corrosive fumes. From 1 to 1000 hp.



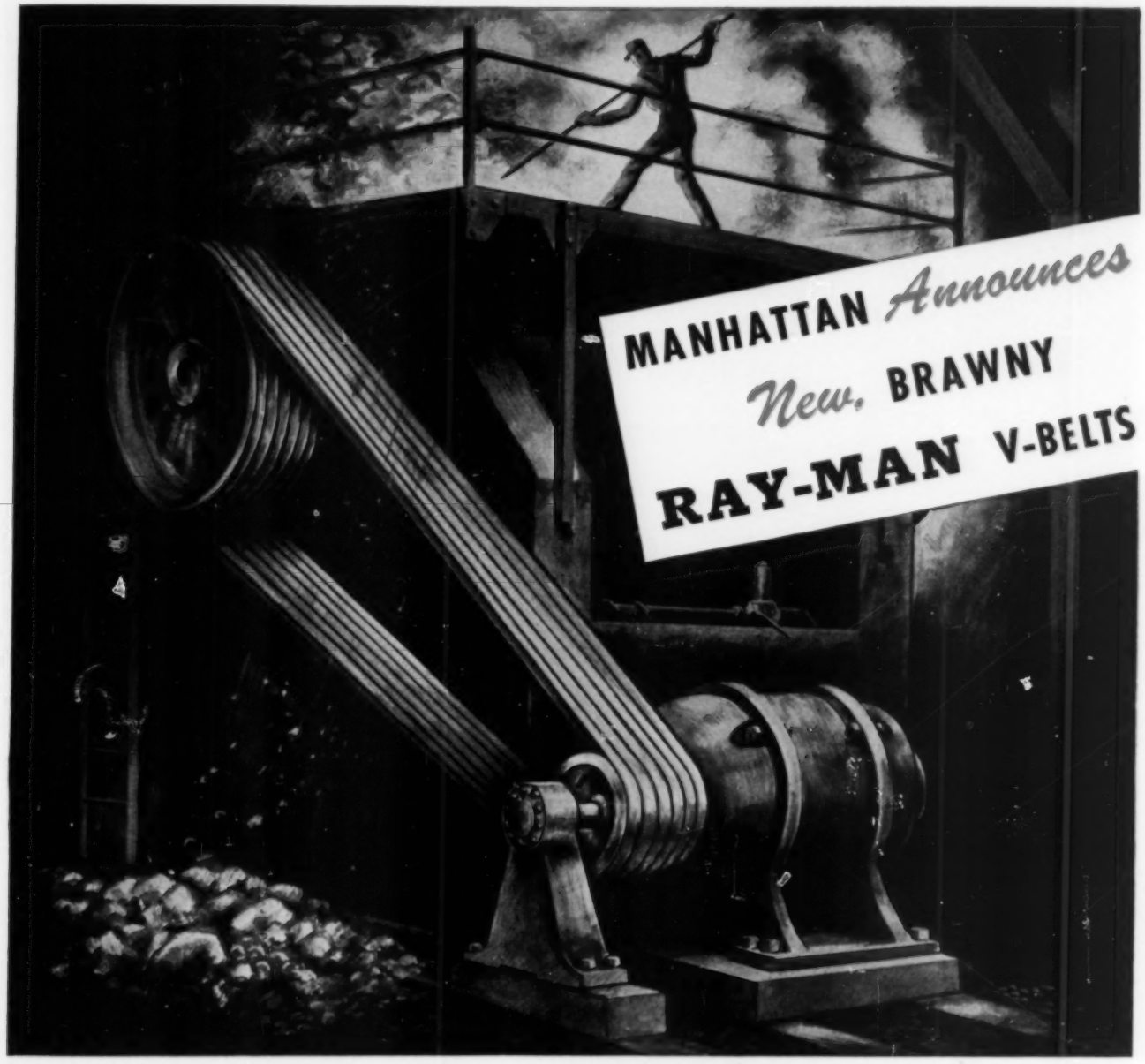
G-E gear-motors for low-speed operation. A normal-speed motor with built-in reduction gear. From ⅛ to 75 hp.



G-E synchronous motors for maintaining exact speeds or for correcting power factor. From 20 to 1000 hp.

YOU CAN'T BEAT TRI CLAD

EXTRA PROTECTION



for tough, rugged drives

The new RAY-MAN V-BELTS, developed by Manhattan engineers, are an outstanding contribution to industry. Here are the distinctive features of new RAY-MAN V-BELTS:

OIL-PROOF . . . NON-SPARK . . . HEAT-RESISTANT

Special-Engineered Strength Members absorb shock better. They are protected against Moisture, Shrinkage and Oxidation.

If you have a particularly troublesome drive that has been hard on belts and expensive to maintain, call your Manhattan representative to tell you about RAY-MAN V-BELTS.

Manhattan's research-inspired leadership has brought you great benefits—will bring you more . . . "Keep Ahead with Manhattan"

RAYBESTOS R M MANHATTAN

RAYBESTOS-MANHATTAN INC.

MECHANICAL RUBBER PRODUCTS — RUBBER COVERED EQUIPMENT — FRICTION MATERIAL — ASBESTOS TEXTILES
PACKINGS — POWDERED METAL PRODUCTS — ABRASIVE & DIAMOND WHEELS — BOWLING BALLS

MANHATTAN RUBBER DIVISION **PASSAIC, NEW JERSEY**

"In this installation, because of the extremely corrosive character of the water, all pump parts in contact with water are made of Austenitic Chromium-Nickel Stainless Steel."
INGERSOLL-RAND COMPANY
ANACONDA'S UNDERGROUND CENTRAL PUMP STATION
provides room for 6 pumps, 23 feet below the 3800 drainage level of the High Ore Mine. This view shows 3 Ingersoll-Rand 6-RT-4 pumps . . . each a 4-stage unit of 1500 gpm capacity, driven by a 700 hp motor mounted on the same base.

Ingersoll-Rand pumps . . . *with all vital parts made from nickel-containing alloys* . . . were selected for severe service in Anaconda's central pumping station which serves several mines at Butte, Montana.

To assure continuous, dependable performance, The Cameron Pump Division of Ingersoll-Rand Company equipped these units with casings, casing rings, impellers, impeller rings, channel rings, channel ring bushings, cross-overs and glands cast in an austenitic stainless steel containing 11 per cent nickel and 28½ per cent chromium.

Shafts are of stainless steel containing 9 per cent nickel and 18 per cent chromium. Other stainless steel applications include shaft sleeves containing 5 per cent nickel and 18 per cent chromium and intermediate sleeves which contain 11½ per cent nickel and 23½ per cent chromium.

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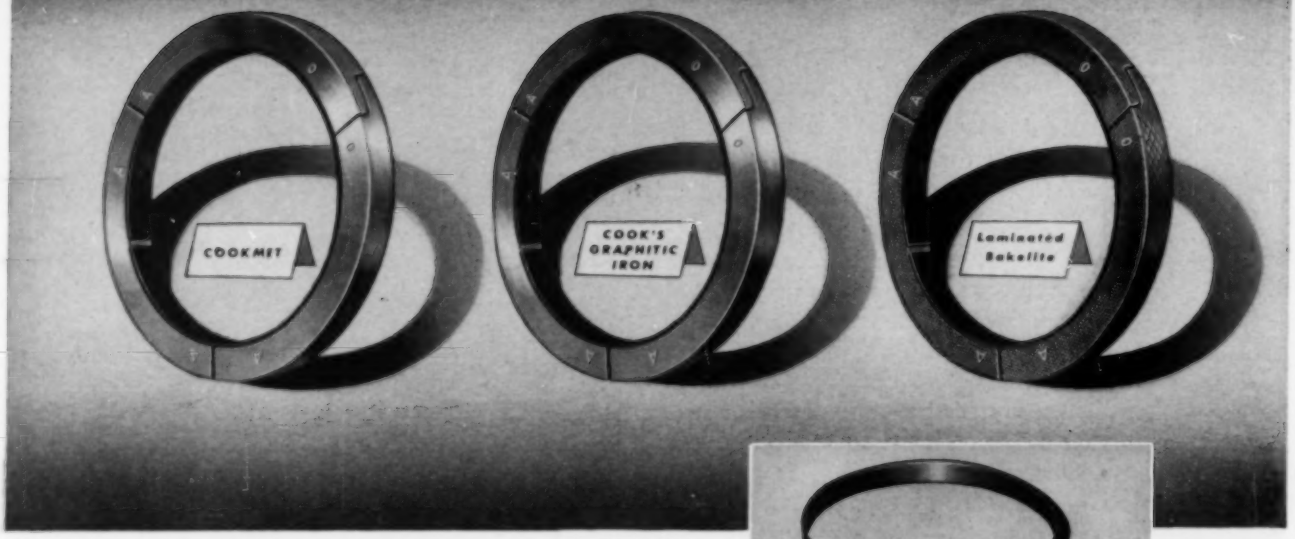

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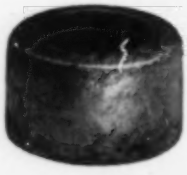

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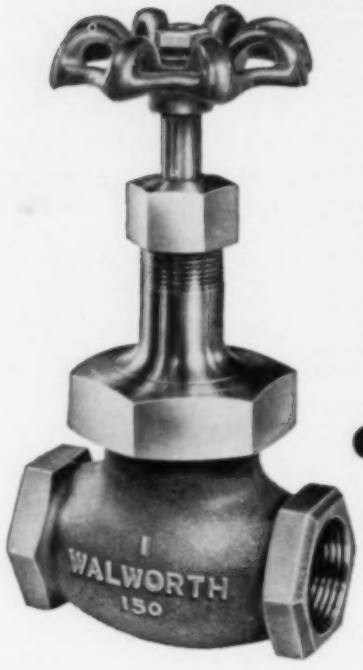

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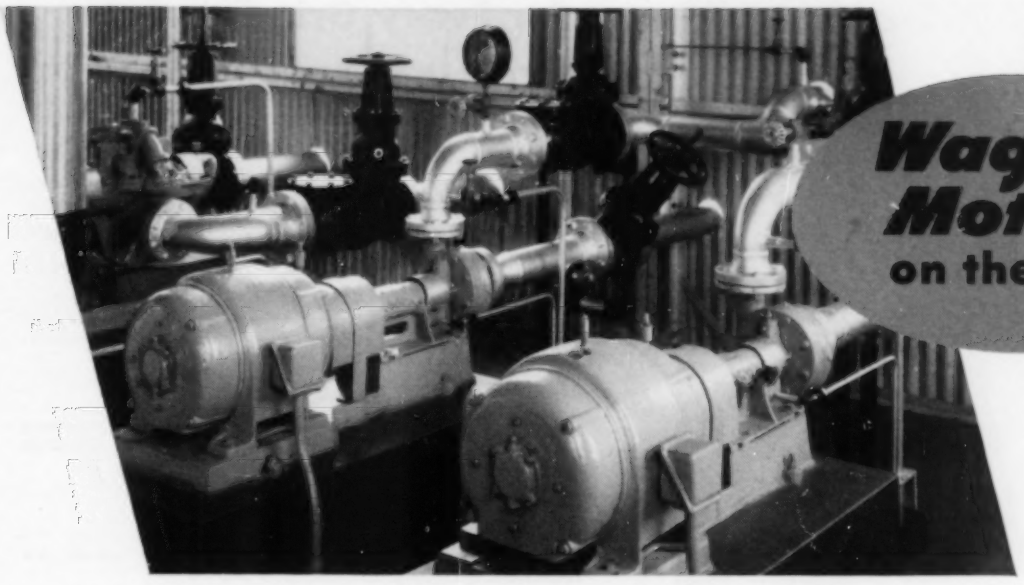

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The installation above shows Wagner splash-proof polyphase motors driving water circulating pumps at a large oil-processing plant in Louisiana.

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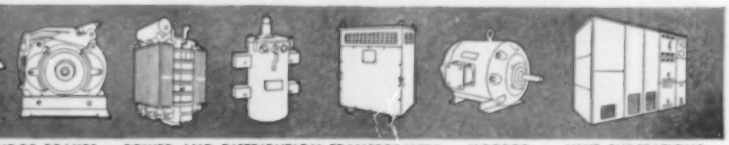

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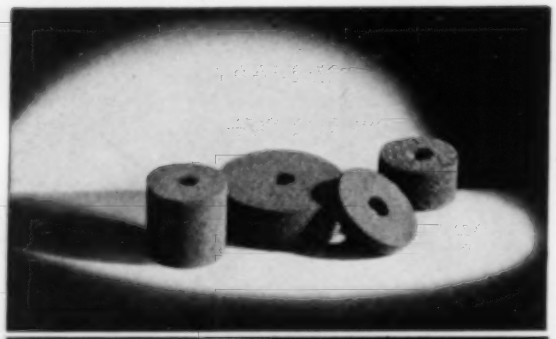

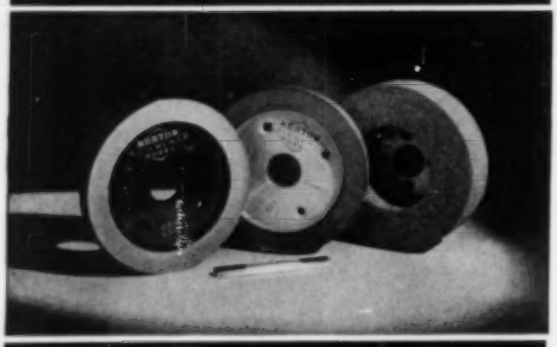

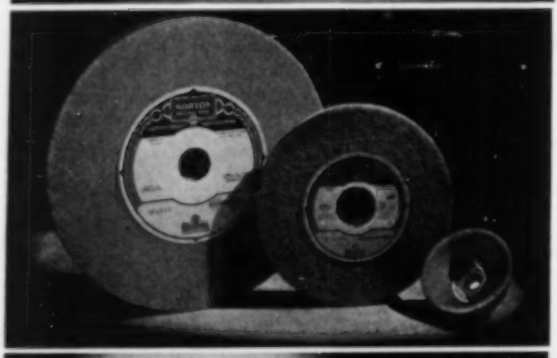

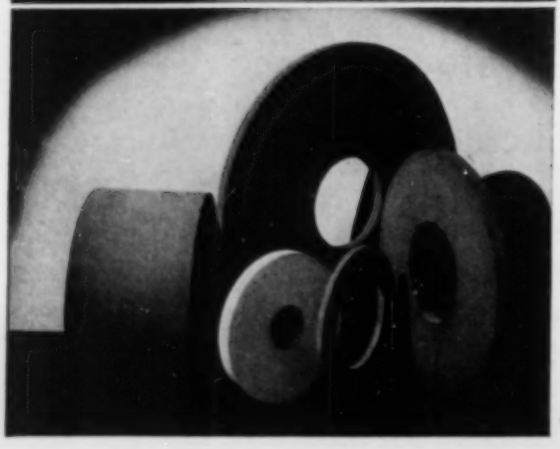

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A complete line of small, accurately made wheels for modern automatic internal grinders as well as for tool room use. Especially effective for internal grinding are wheels of the new 32 ALUNDUM abrasive.

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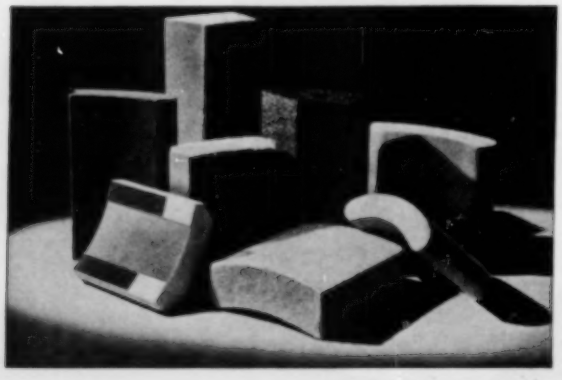

ON THE COVER

THE downstream section of the concrete spillway of Grand Coulee Dam, called the bucket because of its shape, was damaged by the grinding action of gravel and boulders that were thrown into it when the Columbia River was diverted during the construction period. To give engineers of the Bureau of Reclamation a clear understanding of existing conditions, Harold Maikan, veteran Portland, Ore., diver, examined the bucket and took pictures with photographic equipment he developed for the purpose. Our cover illustration shows him being helped into his diving dress.

•

IN THIS ISSUE

AMERICAN paper mills are turning out their diversified products at the rate of approximately 21 million tons a year, and about half the total output is classed as paperboard. Our production of the latter material has quadrupled since 1921 primarily because of the rapid increase in the use of paper packages and shipping containers. In 1947 the national per capita consumption of paperboard was 144 pounds, more than double that of newsprint. Our first article traces the development of paperboard and describes the operations of the Alton Box Board Company, which runs the largest single "board" machine in the country.

•

THE raw materials processed by paperboard mills are waste paper, straw, and wood pulp, and large supplies of them must be maintained to insure continuous operation. The huge piles of these flammable substances constitute a fire hazard that warrants special attention. At the Alton Box Board Company, emergency fire protection is provided at moderate cost by a diesel-engine power plant that can operate all water-supply pumps as well as a fire pump. The unit also affords standby power for the mill when the regular boiler plant is shut down for repairs. Page 9.

•

APPROXIMATELY half a million barrels of gasoline and other light liquefied petroleum products are extracted daily from natural gas. In many instances, the processing of the gas involves compressing it to the desired operating pressure. This practice gave rise to one of the earliest uses of compressors in the petroleum industry and is still one of their important applications. Natural-gasoline extraction plants have therefore played a leading part in the evolution of modern gas engine-driven compressors. An article (Page 12) reviews this development and contains practical suggestions for getting the best service from these machines.

Compressed Air Magazine

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VOLUME 54 **January, 1949** NUMBER 1

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Published by Compressed Air Magazine Co., G. W. MORRISON, *President;* C. H. VIVIAN, *Vice-President;* J. W. YOUNG, *Secretary-Treasurer.*
Business, editorial, and publication offices, Phillipsburg, N. J.
Advertising Office, 11 Broadway, New York 4, N. Y., L. H. GEYER, *Representative.*
Annual subscription: U.S., $3.00; foreign, $3.50. Single copies, 35 cents.
COMPRESSED AIR MAGAZINE is on file in many libraries and is indexed in Industrial Arts Index and in Engineering Index.

ELIMINATED THE CRACKER BARREL

Following the Civil War, cracker factories sprang up in many parts of the country, and a few years later every important city had one or more. Packed in barrels, which usually remained open in stores, the crackers went stale, broke up, and acquired undesirable odors and tastes. Around 1890, cracker bakers began to combine into regional groups, and three large companies were formed. In 1898, National Biscuit Company was organized to consolidate these and several smaller concerns. Its first efforts were aimed at standardizing the products of the numerous establishments, marketing them under one brand name, and packing them to preserve their freshness. From many suggested names was chosen "Uneeda Biscuit." A paperboard box was designed, a paraffin paper was found to serve as an inner wrapper, and a machine was developed to fold the two into a package that both excluded moisture and protected the contents from contamination of any sort. Uneeda Biscuit was introduced in Chicago in 1899 with a big advertising campaign, and it broke the nation's habit of buying soda crackers out of barrels. It also ushered in an era of distributing food products in packages and greatly stimulated the manufacture of paperboard. The upper picture shows the package essentially in its original form, and the lower one the present package, virtually unchanged except for the representation of the cracker. The decorative border, taken from the Morocco binding of a sixteenth century Grolier volume, is retained, as is the purple background that has been used for 50 years.

PAPERBOARD

BIRTH OF AMERICAN PAPER-BOX INDUSTRY

Col. Andrew Dennison of Brunswick, Me., was one cobbler who didn't stick to his last. Instead, he founded America's first paper-box factory, and from it grew the present Dennison Manufacturing Company which still makes boxes. In Boston, in 1844, the Colonel's son, Aaron, learned that American jewelers imported the boxes they needed from Europe. He urged his father to go into the business, and the latter, then 58 years old, began in the manner illustrated below. With an old shoe knife, he cut out box parts from pasteboard and glazed paper, and his daughters, Julia and Matilda, folded, pasted, and finished them. Boxes of this so-called set-up type consist of a body and a top and are delivered to the packer ready for use. Shoe and candy boxes are common examples. Today huge quantities of paperboard enter into their manufacture.

FROM AN ADVERTISEMENT OF F. C. HUYCK & SONS, ALBANY, N. Y.

Our Most-Used Paper Product

What It Is, Its Historical Background, and How It Is Made by Alton Box Board Company

C. H. Vivian

WASTE paper that you discard today may come back to you in a few weeks or months in a new form. The chances are that it will reappear as a shipping carton, a cereal box, a tablet back, or some other article made of paperboard, for the "board" mills are the big reworkers of scrap paper. They now account for more than half the nation's paper output, by weight, and the proportion is increasing all the while. In fact, the growth of this branch of the industry has been nothing short of phenomenal. Although little-used at the turn of the century, paperboard is now intimately connected with our lives from the cradle to the grave. The baby's talcum powder comes encased in a paperboard box, and caskets are ordinarily lined with paperboard panels. Between birth and burial, countless things of paperboard surround us every day.

The dependence of paperboard mills on scrap has given rise to a vast auxiliary salvage industry. More than half of the paper products made in the United States each year are collected and resold as waste. Some, such as books, may be used for years before being cast aside; others, like yesterday's newspaper, are quickly thrown away. In the big cities,

stores and other establishments regularly dispose of their scrap paper to dealers to reduce the fire hazard. Government offices are large contributors, and the Government Printing Office in Washington obtains bids at stated intervals on its spoilage and trimmings. In smaller communities, the junkman is the gathering agency. Spring house-cleaning time always swells the supply and generally pushes waste-paper prices down a little. Junkmen normally sell to regular dealers who sort the paper, bale it, and ship it to board mills.

Scrap paper is classified into 24 grades under specifications adopted by both the Paperboard Industries Association and the Waste Paper Institute. It brings all the way from $10 or $11 a ton for old newspapers to around $160 for the better qualities such as white ledger stock. The cheaper grades are naturally in the greatest supply. Most of the materials made by the board mills soon get back to them, for their products are generally discarded after one use.

The specifications just referred to list a sizable group of "objectionable" papers such as those that are waxed, treated with oil or asphalt, cloth-bound book covers, and mapping paper. These cannot be reduced by the mills. They also prohibit the inclusion of rags, rubber, cellophane, all metals and rubbish, and various other materials. Nevertheless, these are invariably present in certain grades of scrap paper and account for an average "shrinkage" loss of from 10 to 15 percent.

While paperboard was developed within comparatively recent years, pasteboard, which is somewhat like it, was manufactured in China and Persia centuries ago and in Europe as early as 1580. As its name implies, pasteboard is built up of several layers of paper pasted together. Paperboard, on the other hand, is made in its ultimate thickness on a machine. Although it may consist of several layers or plies of material of the same or differing compositions, they are held together by the intermeshing or felting of the fibres rather than by an adhesive. However, boards are often laminated to give them the thickness desired for certain uses. Thus, it is not always easy to make a clear-cut distinction between the two. One distinguishing feature of paperboard is that it invariably contains waste paper.

The *Dictionary of Paper*, published by the American Paper & Pulp Association, defines paperboard as a sheet of fibrous materials 0.012 inch or more thick. Nevertheless, some products that are commonly classed as paper rather than board are thicker than 0.012 inch. Blotting and drawing papers, for example, sometimes exceed that thickness. As a gauge of the dimensions given, it may help the reader to know that the average playing card is 0.011 inch thick. However, it is pasteboard compounded from several layers of high-grade paper.

Pasteboard was employed for making folding boxes before paperboard was available and probably hastened the latter's development. Such containers were first produced in this country in the home of Andrew Dennison, a cobbler of Brunswick, Maine, in 1844. Upon learning that American jewelers were packaging their merchandise in costly imported boxes, Dennison, aided by his wife and two daughters, established a household industry that matured into the present well-known Dennison Manufacturing Company. But paper boxes did not come into general use until much later.

Meanwhile, some makeshift packages were being utilized by distributors of certain products. Among them were the "parers of tacks" furnished by the manufacturers to hardware merchants. These were mandrel-fashioned, heavy-paper containers having ends fastened in with tacks and string. Eventually, demand created techniques and materials for making boxes of various types. Impetus was given this movement in the 1890's by the newly formed National Biscuit Company, a merger of several cracker bakeries. This concern introduced a new kind of soda cracker which, unlike the unleavened "hardtack" previously in favor, had to be protected against air and moisture to retain its taste and crispness. To accomplish this, a folding paper box was devised with a waxed-paper liner and an outer paper wrapper. This marked the advent of the "Uneeda Biscuit," which caught the public fancy to such an extent that other manufacturers hastened to put their products in boxes.

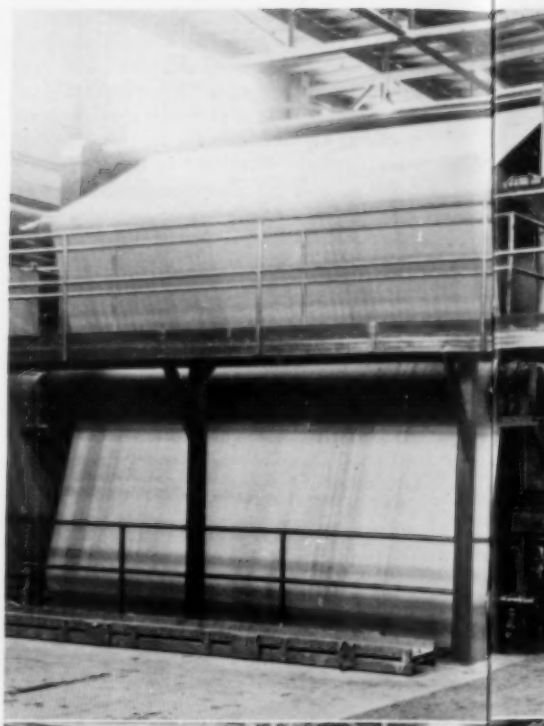
Much of the gain in paperboard output is attributable to the increasing popularity of the familiar paperboard shipping container. Many of us can re-

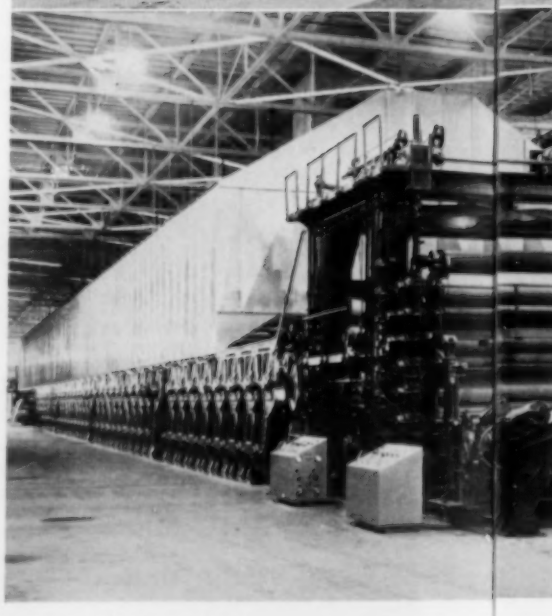
PAPERBOARD CONTAINERS

Folding box board is shipped from the mill in flat sheets and cut to designated size, according to the use intended. It is then printed, die cut, and scored for subsequent folding into boxes. Some large concerns do this work themselves, others have it done by specialists. Illustrated at the right are folding boxes of varied types that received awards in a contest conducted by the Folding Paper Box Association of America. Corrugated containers represent the largest individual end use of paperboard and are now available in many special forms, such as the one shown above. It conforms to the shape of the chair that is shipped in it and also bears a photographic image of the latter on the outside. Paperboard makers are continually improving the surface of the outer ply to facilitate printing and also to increase its resistance to scuffing.

ALTON MILL

The Alton, Ill., mill of the Alton Box Board Company, which produces 690 tons of paperboard daily. At the right are a few of the 90 trailer-trucks that deliver finished material within a 200-300-mile radius and bring back waste paper for reprocessing.





member when most of the things we ate or wore were packed in wood. One could always get a strong, well-built box from the corner grocer for the asking, and larger ones from drygoods merchants. Today they are comparatively rare. In place of them we have paperboard cartons of either solid fibreboard or corrugated construction. The former are for heavy duty and are often reused, an example being cases for bottled beer. The corrugated type is made of board having solid faces or liners and a central corrugated member, which provides a light box with sufficient strength for most purposes.

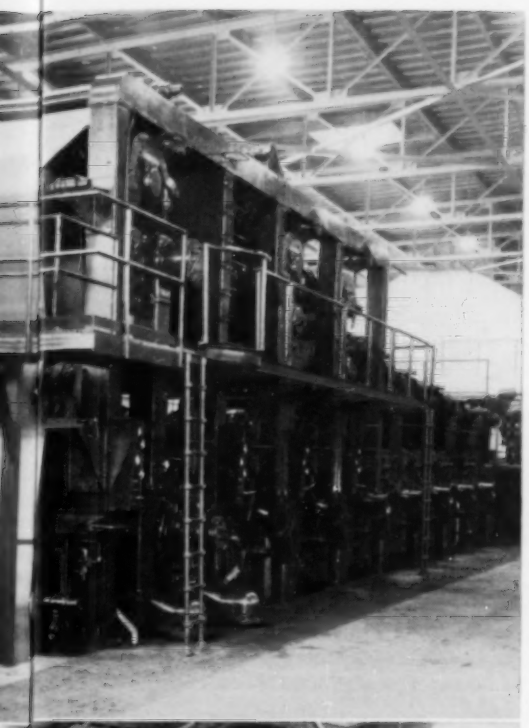
The process of corrugating heavy paper by passing it through rolls or dies was patented in England in 1856 but not applied to the production of containers until 1887. In that year, J. J. Hinde and J. J. Dauch took over, for $2500, a nearly insolvent Sandusky, Ohio, mill which they had been supplying with straw for the manufacture of butchers' wrapping paper. That a strong paper could be fashioned from straw was discovered accidentally in 1827 by William Magaw of Meadville, Pa., who noticed how long straw, with which he lined vessels in which he was extracting potash from wood ashes, matted or felted.

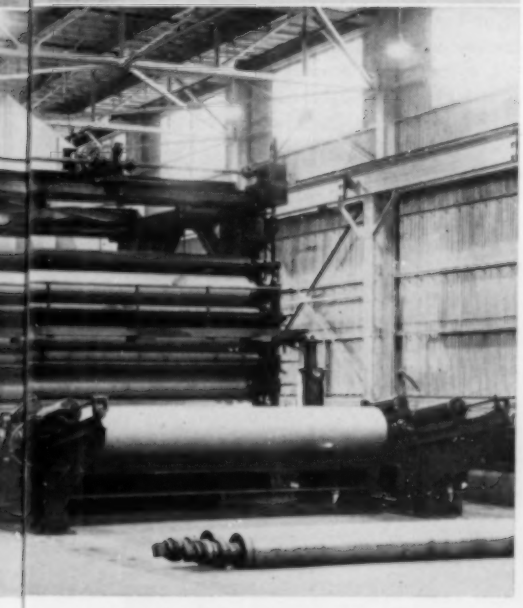
Magaw obtained a patent and began to make straw paper, which was light yellow in color. Although it was used for a time for printing, it attained its greatest application later in heavy grades for wrapping purposes. But the demand for this product was so limited when Hinde and Dauch acquired their mill that they sought additional outlets for it. Somehow they hit upon the idea of sandwiching a corrugated sheet between two solid boards and making boxes from the material. Although they were lighter and cheaper than wood containers, they had to overcome strong prejudice on the part of manufacturers, and that was not easy. By 1894, automatic machines were available for making cartons, and a year later the railway-express companies sanctioned their use for shipments. The railroads, however, did not accept them for ordinary freight consignments until 1906.

A shortage of lumber for boxes gave the corrugated-container business a big lift during World War I, and since then it has grown like a mushroom. Production jumped from 700,000 tons in 1919 to 2,732,000 tons in 1936. In 1939, paperboard entering into all types of boxes, cartons, and packages weighed twice as much as the paper used for books and newspapers combined. Last year, corrugated-box and solid-fibre box fabricators consumed more than 60 billion square feet of paperboard, which accounted for about half the output of the nation's paperboard mills.

Paperboard varies so widely in composition and application that many classifications have arisen. A simple grouping based on the methods of manufacture divides it into combination board and Fourdrinier board. The Fourdrinier paper machine forms the web of pulped fibres on a traveling, horizontal wire screen. After the web has been partly dewatered and consolidated between rolls it becomes wet paper. It is dried by passing it over steam-heated rolls and finished between calendering rolls. By the nature of its action, the Fourdrinier can make a sheet of but one web or ply, which is homogeneous. This restricts its use to the thinner types of paperboard.

Combination board, on the other hand, is built up of several plies, each of which may or may not differ from the others in composition. It is produced on a cylinder-type machine in which the fibre mat is formed on a series of cylinders, called moulds, which are covered with fine wire cloth. Each cylinder revolves, partially submerged, in a vat of fibre, water, and such chemicals as may be required. As it turns, its surface picks up a layer of pulp, from which the water drains to the inside of the mould when it emerges from the liquid. As the cylinder reaches the top of its revolution it comes in contact with a moving, endless belt of felt that is pressed against it by a rubber-covered roll overhead. This serves to transfer the fibre web to the underside of the felt, which then travels to the other moulds and picks up their webs in the same way. The several plies are consolidated into a single sheet by rolling and drying operations, which are accomplished on equipment similar to the Fourdrinier machine. The maximum thickness of such a sheet is around 0.06 inch. Thicker paperboard is made by pasting two or more sheets together.





NUMBER 4 MACHINE

Christened the Altonian by its builder, the Beloit Iron Works, which advertises it as the largest paperboard machine in service, this giant produces a continuous sheet of 196-inch-wide linerboard for corrugated cartons. Its rated capacity is 250 tons daily, but Alton millmen expect to get an additional 100 tons out of it. The upper view shows the wet end with felts carrying a web of fibres from the seven cylinder moulds and rising to pass through a series of primary suction and press rolls before going to the press section proper. In the lower picture the machine is seen from the dry end, with the winding reel in the foreground. In the hooded section are 76 drying rolls, each 5 feet in diameter and weighing about 10 tons. The two boxlike structures with inclined top surfaces standing at the left are the control stations for the entire machine. The latter is equipped with more air-operated mechanisms and appliances than any other so far built for the paper industry.

chestnut wood is processed to extract tannin, the residue is pulped and converted into corrugating board. But, regardless of its origin, it is always 0.009-inch thick. By itself, or with one solid face board, it is used extensively for wrapping bottles for shipment. The term solid container board is self-explanatory. The original shipping containers that first made inroads in the wooden-box business were of that kind. Then it was found that a box of comparable strength but much lighter could be manufactured with a corrugated intermember. Solid container board that is made entirely of scrap paper is called chipboard.

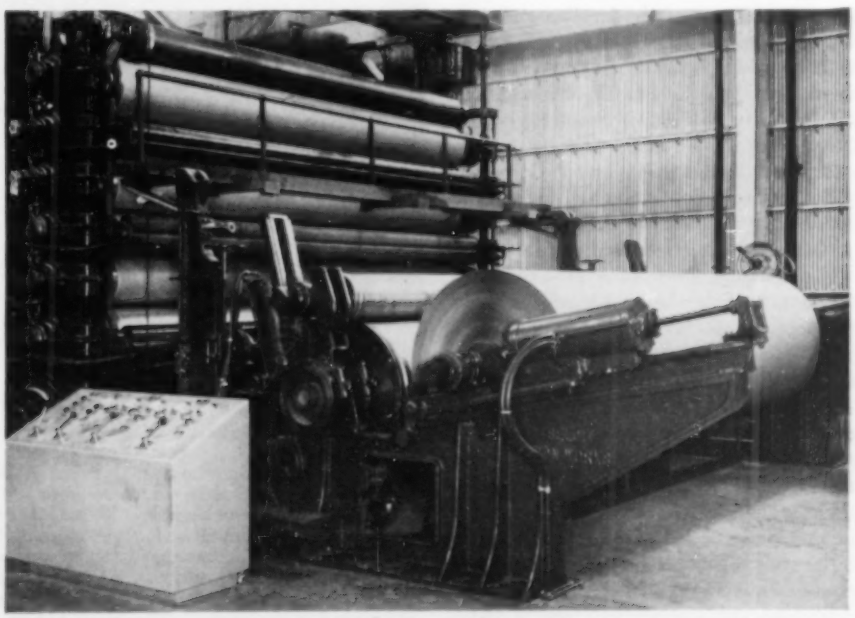
Box boards are subdivided into folding and set-up types. Folding board is cut by the mill to the size wanted by the user and delivered in flat sheets. When die cut, folded, and glued, each sheet forms a container. The board varies in thickness from 0.013 to 0.053 inch and is of such construction that it can be scored, bent, and folded without rupturing. Cereal and soap-flake boxes are examples of its application. Suit boxes are made of a distinctive kind of folding board called mist gray.

Set-up boxes are shipped to the packer ready for use and generally consist of a body and a cover like shoe and candy boxes. Board for them must be stiff and rigid. It is always made on a cylinder machine and is from 0.016 to 0.06 inch thick. Miscellaneous board is turned into many and diverse products such as egg-case partitions, automobile panel boards for backing up upholstery, wallboard and building papers, mailing tubes, cans, etc. They naturally vary in thickness and composition.

The raw materials entering into paperboard are known as "furnish." Although virtually all paperboard contains scrap paper, individual plies are often made of virgin paper pulp. For instance, the outer face of so-called jute liner board for corrugated shipping boxes is usually 100 percent kraft pulp. This produces a smooth surface that will take printing well and that has good scuff resistance. Many boards are given special finishes by adjusting the furnish of the exposed ply, by giving it extra calendering, or by adding suitable sizing agents and chemicals. Oftentimes they are colored. On the other hand, board intended for services where appearance is not of impor-

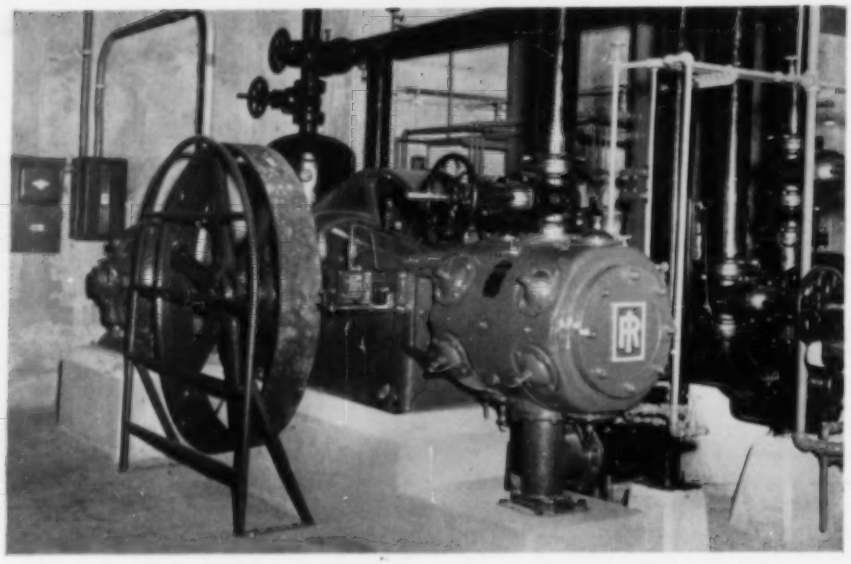
Another classification, from the standpoint of usage, divides paperboard into container boards, box boards, and miscellaneous. Container boards may be either corrugated or solid. The outer faces of corrugated board may be of single or multi-ply construction. Board of this type that is to be fabricated into shipping containers must meet the definite physical standards adopted by the various traffic agencies. For instance, Rule 41 of the Consolidated Freight Classification prescribes a minimum thickness and a bursting strength of at least 200 pounds per square inch.

The corrugated member is commonly made of straw pulp, but other materials are utilized. In southern states where



WINDING REEL

Air cylinders control the tension on the sheet to insure a tight, evenly wound roll. The final stack of calender rolls is shown, and here, too, pressure is controlled pneumatically.



AIR COMPRESSOR

The new No. 4 paperboard machine is so dependent upon compressed air that this 100-hp., belt-driven unit is set up close to it. The machine normally takes air from the plant distribution lines, which are supplied by two other compressors that are duplicates of the one shown. However, if the regular supply fails or if a heavy demand for air causes the pressure to drop to a predetermined point, the reserve compressor starts automatically.

tance may be composed entirely of waste paper. As an example of the varied contents of these products take the case of furnish for board for mist-gray suit boxes. It is made up of 62 percent mixed papers, 10 percent used newspapers, 5 percent newspaper blanks, 5 percent overissue newspapers, 12 percent unbleached sulphite pulp, 5 percent corrugated box clippings, 0.45 percent black felt, and 0.9 percent kraft pulp, plus chemicals.

As of December, 1947, there were in the United States 246 paperboard mills containing 433 machines of which 336 were of the cylinder type and 97 of the Fourdrinier type. They were located in 35 states and had a combined daily capacity of 38,153 tons, equivalent to 11,826,000 tons per year (on a basis of 310 operating days).

For a look inside a modern board mill, we will go to Alton, Ill., 30 miles from St. Louis, Mo., and on the Mississippi River. Situated there is the original and largest of three mills of the Alton Box Board Company, which currently produces some 690 tons of board a day on four Beloit cylinder-type machines. The concern started business at Alton in 1911 with one 4-cylinder unit having a rated daily capacity of 40 tons of 132-inch-wide board. Since then, by adding four cylinders to the machine and replacing virtually every part of it, its per diem output has been increased to 180 tons.

As demand warranted, a second, third, and then a fourth unit were set up. No. 2 can produce 130 tons of 108-inch-wide material daily. No. 3 machine, which makes only strawboard, can now turn out material 164 inches wide at the rate of 130 tons a day, although it originally produced a mere 20 tons. No. 4 machine, which went into operation late in 1947 and is still undergoing refinements, is reputedly the largest of its kind. It makes linerboard 196 inches wide. Its rated capacity of 250 tons a day has already been exceeded, and mill officials confidently predict that they will bring it up to 350 tons or more.

This giant, with its auxiliary equipment, occupies a new 100x620-foot addition to the mill. When more drier and finishing rolls are in place, it will have a length of around 600 feet, or approximately two average city blocks. To prepare the stock, to pump it and the water used in processing it, and to run the machine, 6500 kw. of power is needed. Its seven cylindrical moulds on which the web is formed are 5 feet in diameter and driven by individual motors. From the cylinders, the sheet, adhering to its felt carrier, is passed over two suction rolls, through a pair of press rolls, and then over a third suction roll. Now strong enough to support its own weight, it goes from the felt to the press section, where the first of two sets of rolls merely exerts pressure. The second set consists of a press roll, which is on top, and of a suction roll. Thus, suction is applied to the web at four points after it leaves the moulds.

Now well consolidated, the sheet enters the drier section with its 76 driers, each 5 feet in diameter and weighing about 10 tons. Finally, it passes through

"JUNKER" AND "RAGGER"

Although waste paper is theoretically free from nonpulpable materials when it reaches the mill, it actually contains from 10 to 15 percent of foreign matter which is removed during the beating process. Solid objects come out via a junk remover. They are elevated by chain buckets and delivered to a bin from which they are raked into cars for disposal. Note the rubber boot in the car at the left. The man in charge of the junker scans the refuse closely and occasionally is richly rewarded. Currency, which has presumably been placed in books and then forgotten, is not reduced by the beater and comes out with the trash. Coins are often found, and even diamond rings. Rags, rope, and wire affix themselves to wire that is purposely placed in the beater. The tangled mass (right hand in the picture) builds up to a thickness of a foot and more and is periodically drawn back a few feet over the side by means of tackle. It has to be sawed into sections to permit handling for disposal. Over the years, hundreds of tons of rejected material has been used to fill up low areas on the mill property, and it is commonly believed among the employees that it contains a fortune in money and jewelry that escaped detection at the junkers.

HARVESTING "HAY"

Although paperboard machines function very dependably, something goes wrong now and then and the sheet breaks. Also, when restarting after a temporary shutdown a little time is often required to get a continuous sheet threaded through the multiple rolls. On such occasions considerable waste board accumulates under the machine. In mill parlance it is called "broke," somtimes "hay." Older machines usually stand over relatively shallow pits from which it is a sizable job to retrieve the waste. The new No. 4 at Alton has a full basement beneath it, and the "broke," as well as the trim removed from the sides of the sheet to even the edges, falls in the clear where there is ample room to handle it. This is done by means of a cable-drawn scraper operated by an air hoist (left) mounted at the top of an inclined conveyor. The scraper, handled by two men, pushes a batch of waste along the concrete floor to a conveyor (right), which elevates and delivers it to a cross-running conveyor leading to a reprocessing beater.

the calender rolls, which impart the desired finish. An innovation so far as cylinder-type machines are concerned is the interposition of two drier rolls between the two stacks of calender rolls. Their purpose is to remove the water added at the first calender rolls to produce a smooth surface. The finished sheet is wound on a reel into a roll weighing between 5 and 6 tons. This is transferred to a separate rewinder, where the material is edge-trimmed and slit lengthwise as it is rewound into rolls of the required length and girth for shipment to fabricators.

The entire machine is operated by a Westinghouse 1500-hp. steam turbine, which turns a line shaft extending the full length of the unit. Belts from the shaft drive the individual sections through enclosed hypoid gears. Air-operated clutches contribute to smooth functioning and precise control. In drying gradually the sheet stretches, and to maintain the proper tension on it the rolls in the drier section must turn progressively faster as it advances. At an operating speed of around 400 feet per minute this calls for delicate adjustment. To insure positive lubrication of all parts of the driving mechanism, a tank car of oil is kept in circulation by pumps.

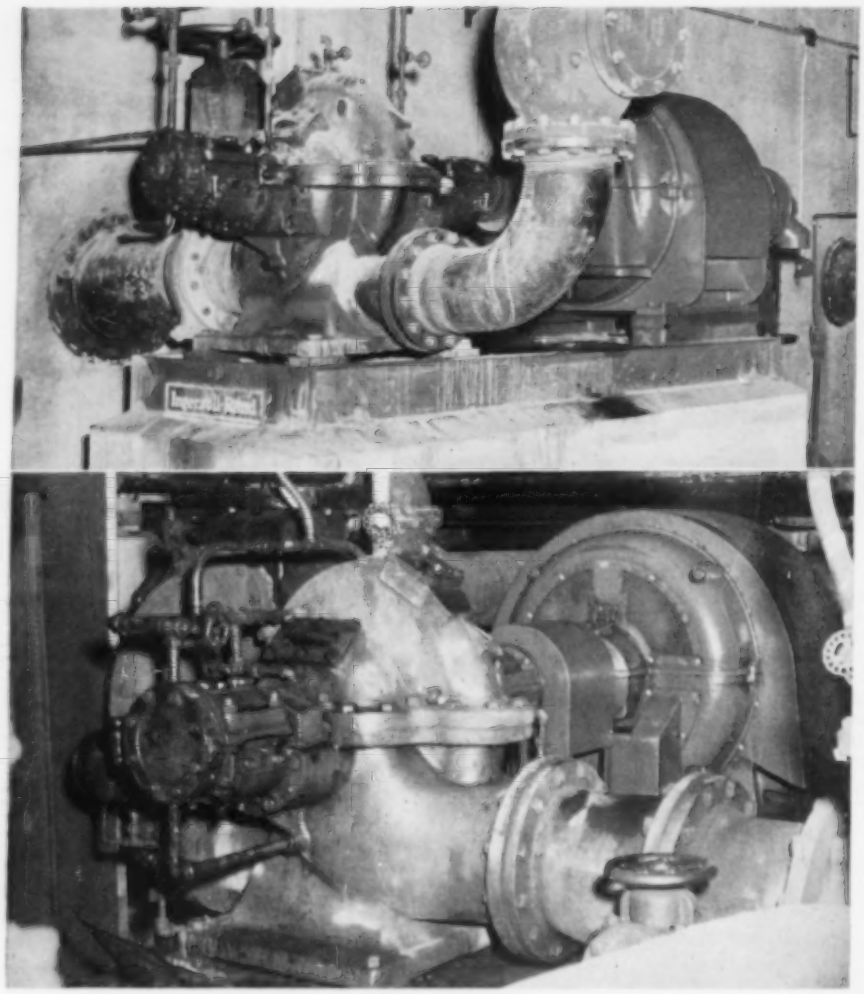
There has been a tendency in recent years to use compressed air extensively on board and paper machines, and this one probably has more pneumatic appliances than any previously built. In addition to the applications already mentioned, air serves the following purposes: to maintain the desired loading pressure on press and calender rolls; to raise or lower one end of a roller over which the felt passes so as to keep it in its proper path; to stretch the felt which, when new, tends to contract when it comes in contact with acidic chemicals used to condition it; to operate stop brakes on the drier rolls; to lift the rider roll on the winder; to maintain the desired pressure on the doctor blade, which is a scraper bearing on the sheet as it passes over a roll near the discharge end to remove adhering bits of paper or pulp, excess size, etc.; and to control the tension of the sheet at the winding reel to insure a tight, compact roll.

Because compressed air is essential to the operation of the machine, a new compressor is located close to it. This Ingersoll-Rand 14x13-inch single-stage unit is a duplicate of two compressors that have served other parts of the plant for some years. Under ordinary conditions the older compressors supply No. 4 machine with air, but if they should stop for any reason or fail to meet the demand the new unit will start up automatically.

Preparation of stock for board machines parallels the final stage of the process as practiced in paper mills. Except in the case of straw, cooking is not required because the waste paper that serves as raw material has already gone through that operation and consists essentially of cellulose fibres. It is only necessary to remove rubbish and nonpulpable substances from the scrap and then to separate the fibres so that they can again be matted into a new sheet.

At Alton, the bales of scrap paper are unloaded from either railroad cars or trucks and sent to breaker-beaters which, as the name indicates, break down the fibres. In general, there are beaters for each of the different kinds of furnish, and each has its complementary equipment. In the beater, essentially a large tub, the paper, immersed in water, is given a circulating motion. During each revolution it passes under a heavy roll that is fitted with transverse metal bars and turns past a bedplate similarly equipped. Repeated treatment cuts, brushes, and splits the fibres. In older-type beaters, trash which floats is raked off and that which sinks is removed when the vat is periodically emptied. A new beater, called a Hydrapulper, performs these cleaning operations mechanically. By centrifugal action, extraneous and nonpulpable solid materials are thrown out to the perimeter of the vessel where they are caught and elevated to a bin from which they are withdrawn by gravity.

To catch rags, string, and similar light materials, multistrand baling wire is hung over the side of the vat so that one end is submerged. Wire that binds the bales is dropped into the tank with the paper, and more is introduced from time to time. As it circulates, this wire becomes intertwined with the rags and ropy stuff and fastens itself onto the ends of the strands extending into the vat. This self-perpetuating "ragger," as it is known, grows to a diameter of a foot or



PUMPS

As is true of all paper mills, this one consumes vast quantities of water. The daily supply of raw water, averaging 4½ million gallons, is initially handled by an Ingersoll-Rand 10-inch, single-stage pump (lower picture) which has a capacity of 3500 gpm. against a head of 150 feet and is driven by a 200-hp. Westinghouse motor. However, this water is reused so many times that all the pumps on water service, excluding those handling paper stock, circulate approximately 48,000 gpm. through the mill, or more than thirteen times the initial input. Between uses the water is stored in concrete chests or reservoirs. Shown at the top is another Ingersoll-Rand pump adjacent to a chest of 56,000 gallons capacity from which it transfers the water to the head boxes of No. 4 paperboard machine. Virtually all centrifugal pumps on mill-water service have three hand-hole covers that can be quickly taken off in case it is necessary to remove rags or other extraneous materials that occasionally clog passages.

so, and from time to time is drawn a few feet over the side by tackle.

If a stock is intended for the outer ply of a sheet, then a mineral filler, such as clay or chalk, and size such as rosin or alum are sometimes used to improve the surface finish for appearance, printability, or scuff-resistance. For the most part, these are put into the beater. Coloring agents, usually aniline dyes, may also be added at that stage.

By screening it and passing it through settling tanks while suspended in 99 parts water, the pulp is freed of sand and small metal objects such as pins and paper clips which sink, as well as of bits of cork or other floatable material which rises and is skimmed off. It is next refined in a Jordan or Claflin. The latter consists of a conical rotor fitted with longitudinal steel ribs which bear upon similar ribs on the inside of a slightly larger shell of the same shape. There the fibres undergo abrasion, rubbing, and cutting that further divide and soften them. After more screening, the stock is ready to be pumped to chests from which it is fed as needed to the board machines.

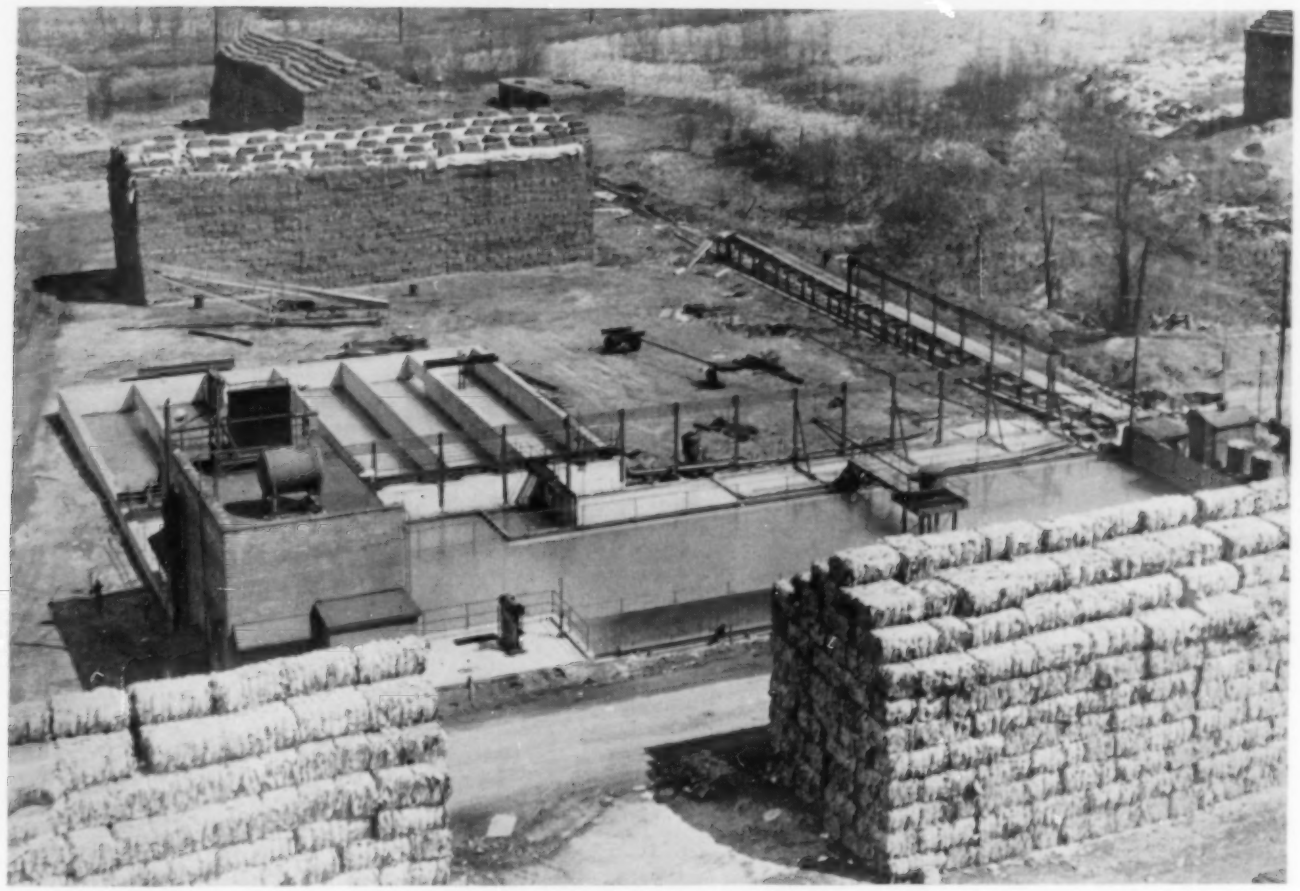
To release its cellulose fibres, straw is cooked in spherical digesters holding approximately 4½ tons each. Caustic soda and steam at 50 pounds pressure are introduced, and each batch is treated for from four to five hours. The steam is then blown off and the charge dumped by rotating the vessel. After the caustic has been washed off, cellulose fibres from 8 to 20 inches long remain. They are shortened, subdivided, and pulped in beaters and Jordans.

Approximately 1.8 tons of water has to be removed from every ton of board made, and because much of this is evaporated by steam injected into the drier rolls it is apparent that large quantities are required. It is therefore economical for mills to generate their own power with steam and then use it in the machines. At Alton there are six boilers which develop 340,000 pounds of steam per hour. Four of them burn coal and are fired by chain-grate stokers; another one regularly consumes natural gas, but can burn oil; while the most recent unit can be fired with powdered coal, gas, or oil, or any combination of the three. It is equipped with Hagan air-operated combustion controls. The air is normally taken from the plant's distribution lines, but an Ingersoll-Rand Type 20 compressor in the boilerhouse cuts in automatically when the regular supply fails.

Electric power is generated by four turbogenerators. One 1500-kw. condensing unit is arranged to permit extracting steam at 5 psi. pressure for heating the water in the beaters. Three other machines of 1500-, 2500-, and 5000-kw. capacity, respectively, utilize steam at 450 psi. pressure and 750°F. Steam is withdrawn from them at 150 psi., and they exhaust at 50 psi. In addition to drying paperboard, steam drives the turbines that run three of the board machines. It also operates two twin-cylinder Hamilton-Corliss engines of 1200-hp. each that have been driving some of the original beaters and Jordans through line-shaft and belt connections since 1911.

The mill consumes daily around 4½ million gallons of water, which is obtained from wells as described in the following article. As is customary in paper mills, much of this water is used many times, being discarded only when it is unfit for further service. Actually, approximately 48,000 gpm., not including paper stock, is handled by the many pumps that are required to circulate the water through the varied equipment and to deliver it to chests or reservoirs where it is stored between applications. Ten of the chests are equipped with float switches that actuate air-operated valves to start pumps when the liquid reaches prescribed levels.

Operating executives and personnel at the Alton plant are: M. W. Swaim, executive vice-president and general manager; R. H. Breyfogle, vice-president in charge of manufacturing; R. Frank Hollis, general superintendent; H. M. Breyfogle, mill superintendent; B. T. Storm, chief draftsman; J. F. Kochersperger, master mechanic; M. D. Jones, chief operating engineer; and J. K. Cushman, mechanical engineer.



RESERVOIR AND EMERGENCY PUMPING STATION

A view from the roof of the mill powerhouse of the million-gallon reservoir and the structure that stands over one corner of it and houses a diesel-engine generator set and a fire pump. Portions of two piles of baled waste paper are in the foreground and two stacks of baled straw in the background. Supplies of these and paper pulp at times aggregate 55,000 tons and are disposed throughout an area 3000 feet long. For their fire protection dependence was previously placed primarily upon a steam-driven pump that would be inoperative if the mill boiler plant should go out of commission for any reason. The diesel pumping plant was provided as asafeguard against such a contingency.

Emergency Fire Protection

Provided at Alton Mill by Standby Diesel Power Plant and Pump

A LARGE paperboard mill uses daily hundreds of tons of bulky raw materials, principally waste paper, and must therefore maintain adequate stocks on or close to its property. Mills ordinarily arrange to have a 3 or 4 weeks' supply of scrap paper in the warehouses of the packers from whom they buy it, but to safeguard themselves against interruptions in shipments occasioned by storms, strikes, and other unforeseen causes they also keep sizable inventories on hand.

Past experience indicates that these local reserves should approximate 10 percent of a mill's annual requirements. The amount stored varies during the year, being normally higher in winter when transportation is most difficult and uncertain. It is also influenced by fluctuations in market conditions. To insure a continuing source of raw material, well-financed mills often take more waste paper than they currently need in order to stabilize the price and thus protect their suppliers from possible losses that might put them out of business.

The Alton, Ill., mill of the Alton Box Board Company obtains its scrap paper from the surrounding territory—from within a radius of 200 or 300 miles. It maintains a fleet of 90 trailer trucks to deliver finished products as far as Chicago to the north and Memphis to the south. These carriers ordinarily haul raw materials back to the plant. Other supplies arrive by rail. In addition to paper, the mill consumes large quantities of straw and lesser amounts of paper pulp. The straw comes from the neighboring farming area and is trucked in by farmers or "balers" every day when the weather is favorable. However, these deliveries decrease or cease during periods of stormy weather, so ample reserve stocks must be maintained.

All three raw products reach the mill in bales, which are fastened with either galvanized wire or metal straps. A "standard" bale of paper measures 72x 32x28 inches and weighs from 900 to 1000 pounds, depending upon the material. Actually, many weigh as much as 1500 or 1600 pounds, while a few from

DIESEL BUILDING

On top of the structure, at the left end, is a fan-type radiator which serves to cool the fluid that cools the diesel engine. Also on the roof is a storage tank that holds enough fuel oil to operate the engine for 40 hours. At the left edge of the picture is a motor on top of one of the deep wells that supply water to the reservoir.

small suppliers run from 100 to 250 pounds. Bales of straw weigh from 70 to 100 pounds each, and pulp is ordinarily compressed into 500-pound bundles.

Following the usual industry procedure, paper and straw are stored outdoors by tractor-mounted cranes in large, well-made piles with adequate space between as a fire-protection measure. Paper stacks normally contain around 1000 bales, and straw "ricks" up to 13,000. Because these materials undergo some deterioration if left exposed too long, the piles are located on dry, well-drained ground, succeeding tiers being built up carefully according to a definite pattern. The bales are interlocked so as to minimize moisture penetration and to prevent separation and bulging.

Although some mills cover all paper and straw with galvanized-steel sheets, this is not always done at Alton because the materials are used before they can suffer damage. Stocks that have been longest in storage are the first to be withdrawn, and all piles are consumed within safe time limits, as determined by experience. Being the most expensive of the three raw products, pulp bales are stacked in open-sided sheds having sheet-iron roofs that protect them from rain and snow.

Materials storage at Alton is apportioned among four distinct plant yards distributed over an area that measures 3000 feet from end to end. At times the many piles contain up to 5000 tons of pulp, 20,000 tons of paper, and 30,000 tons of straw. Obviously, these stores represent a heavy investment, warranting adequate safeguards against fire loss. It is important that these inventories be preserved not only because of their monetary worth but also because they are vitally needed to keep the mill running at certain times of the year. During fair weather, the stocks arrive at approximately the rate at which they are used, and the storage piles are drawn upon only for such small quantities as may be required to make up any deficit. During midwinter, however, they are sometimes the principal source of mill supply for days at a stretch.

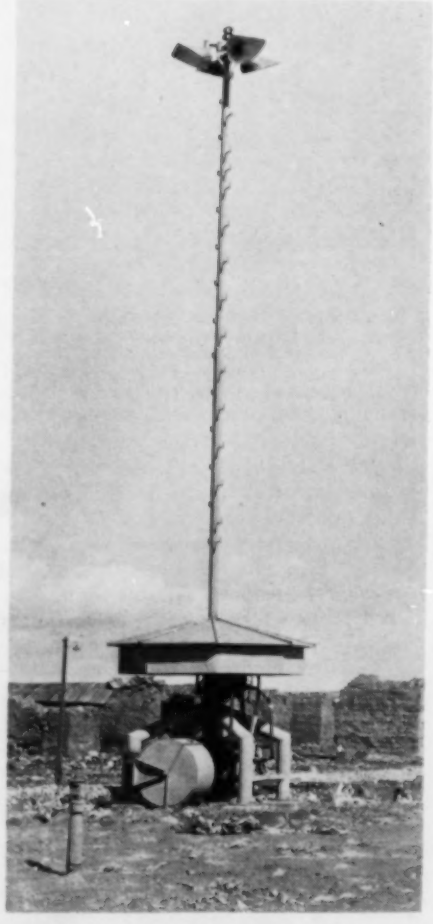
Until the beginning of 1947, sole reliance for fire protection was placed upon a steam-driven pump inside the mill, plus one mobile fire engine equipped with a pump and a small chemical tank. Operation of the stationary pump depended entirely upon the availability of steam from the boilers in the mill powerhouse. This meant that the pump would have been ineffective if all the boilers had to shut down simultaneously for one reason or another. Although there was small chance of this happening, it was definitely within the realm of possibility. Consequently, the potential hazard was eliminated by setting up an independent pumping station with its own source of power.

This emergency equipment is housed in a small brick building located directly over one corner of a 1,000,000-gallon reservoir that supplies the mill with water. The power plant consists of an Ingersoll-Rand Type S, 8-cylinder, 600-hp. diesel engine direct connected to a Westinghouse 500-kva., alternating-current generator that delivers 3-phase, 60-cycle current at 400 volts. The engine is of the 4-cycle, single-acting, solid-fuel injection, enclosed type. Its cylinders have a 10½-inch bore and a 12-inch stroke. Fuel consumption is less than 0.4 pound per brake horsepower-hour.

The engine cooling system is similar in principle to that in an automobile. After circulating through the cylinder cooling jackets, the fluid goes to the roof, where it passes through a fan-type radiator to be cooled and is then returned to the engine. To eliminate the possibility of the fluid freezing in cold weather, it is a mixture of half and half Prestone and distilled water. Also on the roof is a fuel-oil storage tank that holds 1200 gallons, which is sufficient to operate the engine for 40 hours. Two Type 30 air-cooled compressors, one driven by a gasoline engine and the other by an electric motor, furnish air for starting the diesel.

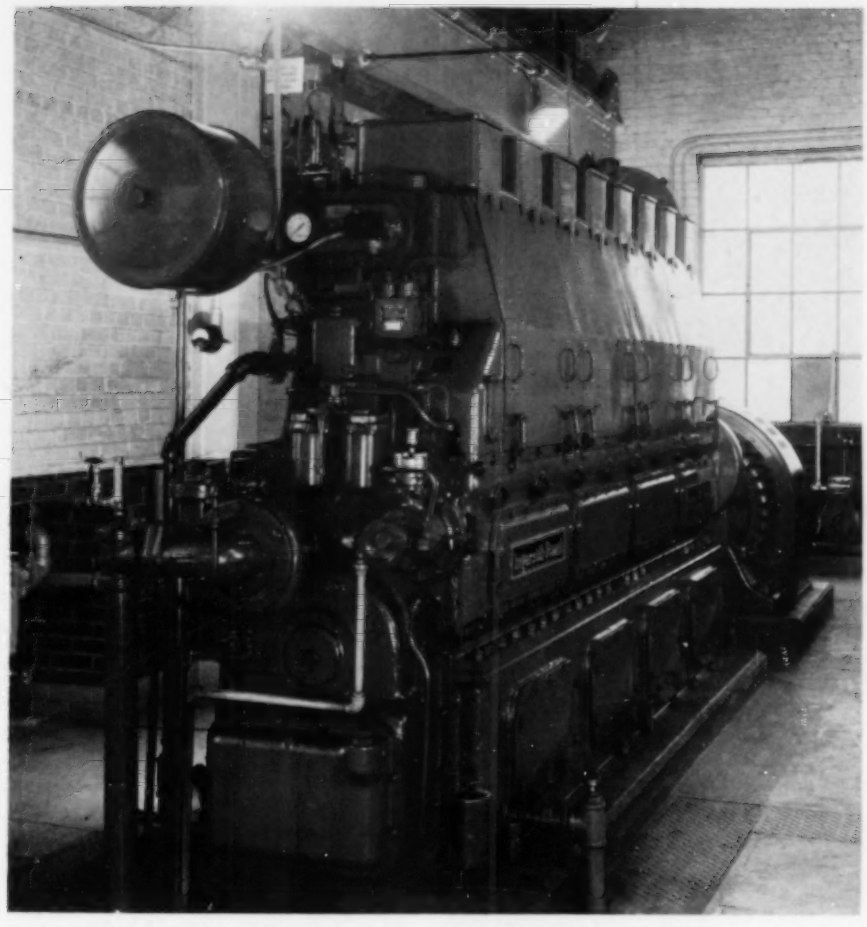
In the same room with the engine-generator set is a vertical, 4-stage, 150-hp. centrifugal fire pump with a capacity of 2000 gpm. at 100 pounds discharge pressure. Its suction pipe passes through the floor and is submerged in the water of the reservoir underneath.

Nine wells, ranging in depth from 110 to 130 feet, supply the reservoir with



FIRE TOWER

Two reels at the base each hold 250 feet of fire hose. Floodlights at the top illuminate an extensive area. In the foreground is a fire hydrant, one of 50 distributed throughout the raw-materials storage areas.



DIESEL-GENERATOR SET

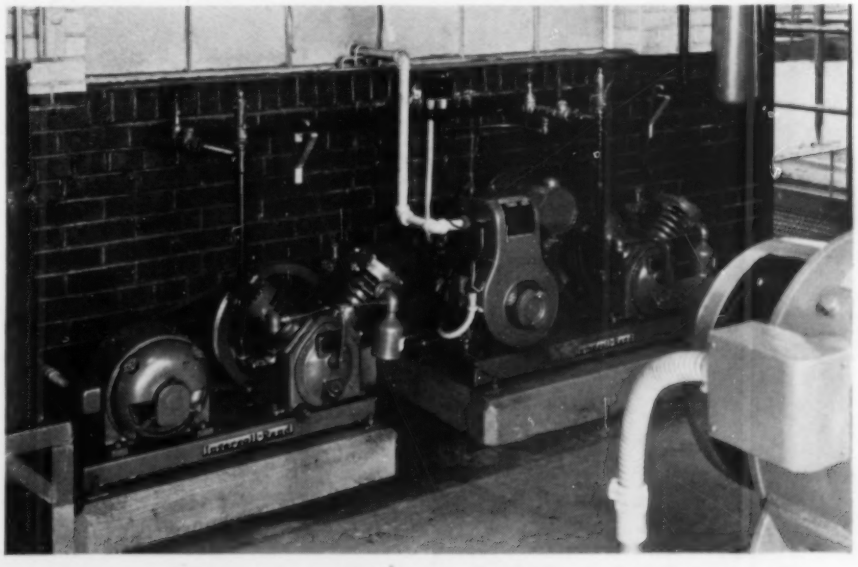
This consists of an Ingersoll-Rand Type S, 8-cylinder, 600-hp., engine direct-connected to a Westinghouse 500-kva., alternating-current generator. In the same room, with its suction pipe submerged in the water of the reservoir underneath the building, is a vertical, 4-stage centrifugal fire pump with a capacity of 2000 gpm. at 100 pounds discharge pressure. As the engine-generator provides enough power to operate the fire pump and the nine 40-hp., deep-well pumps that keep the reservoir filled there is adequate fire protection for all the raw materials, as well as for the mill itself.

water. They are spaced at intervals of several hundred feet, and tests indicate that the underground rock formation is such that they draw upon independent sources rather than on a single large one. Water rises in the wells under natural pressure to within 45 feet of the surface and is pumped from that level by individual deep-well pumps each driven by a 40-hp. motor. As their combined power demand is 360 hp., it is apparent that the engine-generator set will provide enough energy to operate the fire pump and all the well pumps at the same time. Consequently, it affords complete fire protection for as long a period as may be necessary. The engine can be started instantly by merely throwing a switch, and all the equipment will function unattended for a considerable period.

The fire-pump discharge is connected with a system of more than 2 miles of underground piping that extends throughout the raw-materials storage area. The mains are 8 and 6 inches in size, with smaller laterals running from them to the farthermost ends of the yards. More than 50 fire hydrants are spotted at strategic points, and hose houses are located at frequent intervals. A program involving the erection of fire towers at selected places is now being carried out. Each of these consists of a tall steel standard with floodlights on top and with two 250-foot reels of hose at the base. All departments of the mill are protected against fire by a sprinkler system. To make this operative in the event of failure of the regular power or of the mill pump, it is connected with the emergency pumping plant. The latter therefore safeguards the entire plant.

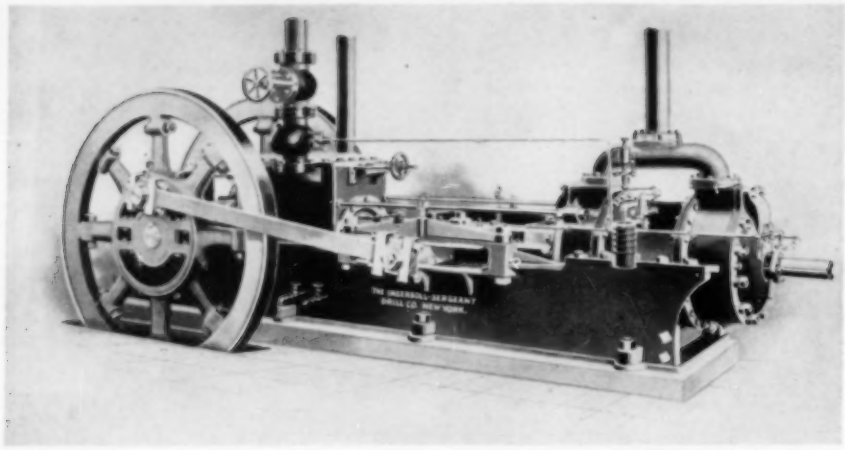
Fortunately, it has never been necessary to call these special facilities into service for fire-fighting purposes. However, the equipment has been used to generate power on two occasions when the boiler plant was shut down over long holiday week-ends to make major powerhouse repairs. Both times the engine-generator set furnished current for the mill lighting system and for operating welding units and other machines needed for maintenance work. To make certain that the machinery is in service condition it is run for a few minutes at regular intervals.

In recent months the Alton mill has been connected with outside public-utility electric lines and now has less need than before for the standby emergency generating and pumping plant. However, it is conceivable that a fire might break out during a heavy storm and at a time when both regular sources of power would be unavailable. Consequently, the reserve facilities still constitute a worthwhile supplemental safeguard that can be maintained at a modest annual capital charge.



DIESEL-STARTING COMPRESSORS

These two 5-hp. air-cooled compressors, one driven by an electric motor and the other by a gasoline engine, furnish high-pressure air for starting the diesel engine.



Compressors in the Natural-Gasoline Industry

A Historical Review of Their Development and Some Suggestions for Operating Them

*J. J. Janzen**

Essential substance of a paper—"Short History of Compressors in the Natural Gasoline Industry and Some A-B-C Operating Rules"—presented October 15, 1948, at the Southern Regional Meeting of the Natural Gasoline Association of America.

THE following historical review of the evolution of natural-gas compressors was compiled from Ingersoll-Rand Company publications and records. In so restricting the scope of the paper, there was no intention to infer that other manufacturers did not participate in their development nor to take any credit away from them. This method of assembling the data was followed merely because of the limited time available in which to study the subject, as well as that allotted for its presentation.

The first mention of a natural-gas compressor built by Ingersoll-Rand was in a bulletin of 1898 which devoted a whole page to this then-novel compressor application. It described and illustrated a good-size, slow-speed, straight-line, steam-driven unit used in an oil field near Fostoria, Ohio, to pump natural gas from wells into a pipe line and stressed the tremendous profit of $25 a day made possible by that procedure. An operator with a king-size handle-bar mustache and with an oil can in his hand was standing near the compressor.

1898 COMPRESSOR

Previously built for handling air, machines of this type were adapted just before the turn of the century for pumping natural gas. Called the Class A, it was a steam-driven unit, with steam and air cylinders at opposite ends of the single frame. Gas entered the compression cylinder (right) through a central pipe connected to the piston. One of these machines delivered 550,000 cubic feet of natural gas daily to Fostoria, Ohio, from wells on the outskirts of the city.

The machine's steam cylinder was next to the frame, with the single-stage compression cylinder in tandem and on the outside. The latter had a piston inlet valve, the hollow piston having a ring valve on each face. The gas-inlet pipe was connected to the piston and extended through the outer head of the cylinder. Mention was made of a swing joint connecting the hollow tail pipe with the incoming gas line. The discharge valves were of the poppet type.

Compressors for natural-gasoline plants did not figure in the company's literature until 1912-1913 because the gasoline industry was at that time still in its infancy. The country's total natural-gasoline production in 1911 was only about 20,400 gallons per day, divided among West Virginia, Ohio, Pennsylvania, California, and Oklahoma, in that order. It would be interesting to speculate on what might happen to this nation now if it should be limited to the use of 20,000 gallons of gasoline for just one day.

The early gasoline plants were of the compression type; that is, the gas was compressed to around 200 and up to 300

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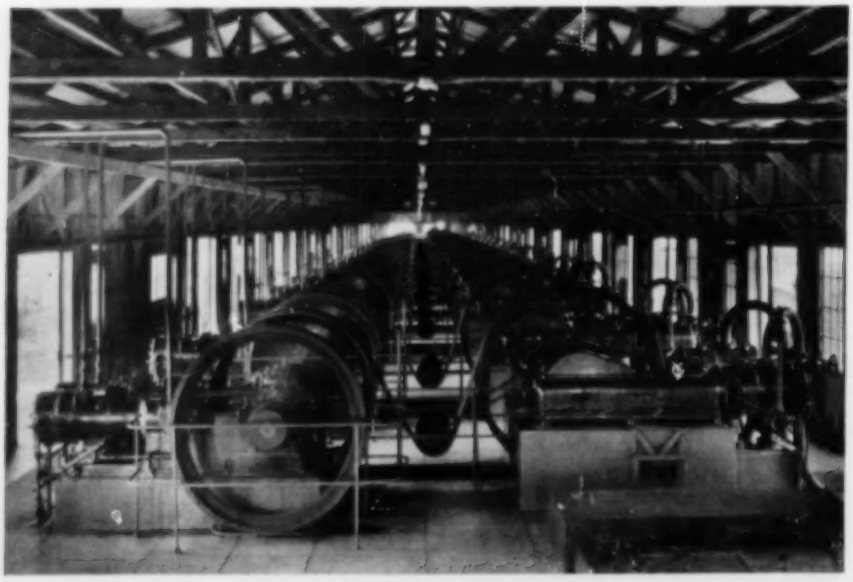


PRE-1920 NATURAL-GASOLINE COMPRESSORS

Gas engines (left) driving duplex compressors through belts in a California natural-gasoline extraction plant around 1917. This makeshift arrangement, which permitted using inexpensive and plentiful natural gas for fuel, was the forerunner of the direct-connected gas engine-driven compressor.

psi. and then cooled in iron pipes exposed to the atmosphere. Sometimes water was permitted to trickle over the pipes, or they were submerged in streams. Naturally, some of those plants were small. Their compressors were usually of 2-stage design, ranging from vertical units of 5 to 10 hp. to intermediate-size, horizontal, single-acting, opposed-cylinder types and to large duplex, horizontal models.

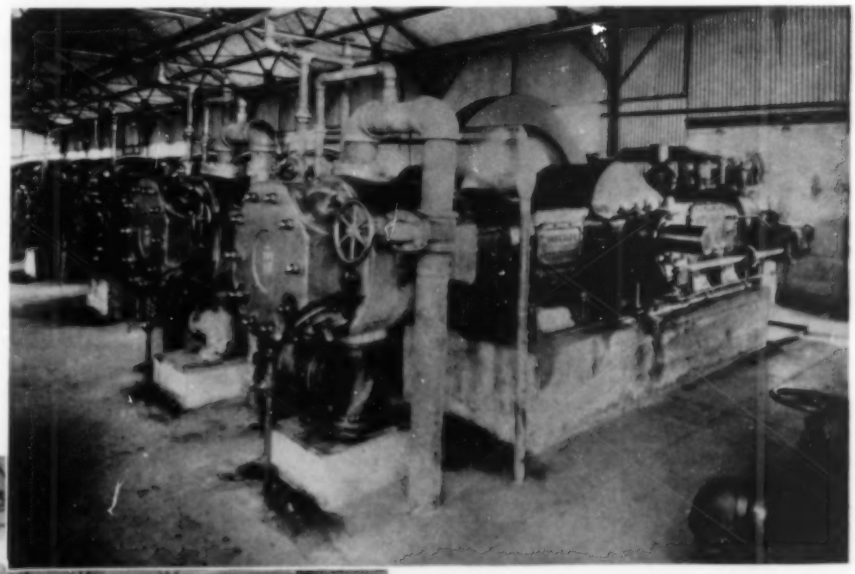
The small and intermediate machines were belt-driven, while the biggest ones had either belt- or direct-connected steam-drive. Piston inlet valves, called Hurricane valves, were used on the first stage of the intermediate and large compressors. Poppet valves were utilized for discharge on all units and also for inlet on the small sizes and on the second-stage cylinders. But it wasn't long before Corliss valves were applied for inlet on both the first and second stages of the largest machines. In those days Russia was one of the most important oil-producing countries, and our company did so much business there that it developed a special belted compressor frame named the Baku after the city which was the center of that field.

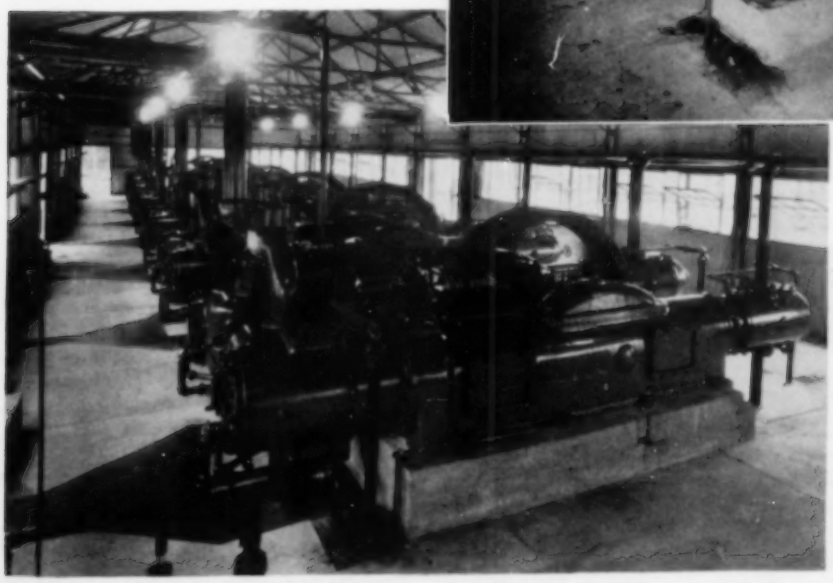
Around 1920, or a little earlier, plate valves were first incorporated in compressors for gasoline plants, the original patent on that type having been bought in Europe by Ingersoll-Rand. By then, natural-gasoline plants had grown in number and size, and vacuum pumps frequently served to pull the gas from wells. Plate valves were initially used on vacuum pumps and for intake on the first-stage cylinders of compressors. With improvements in design, plate valves were substituted for the old piston-inlet, Corliss, and, eventually, the poppet type. The main advantages of the plate valve over the others were: its capacity to operate at higher rotative compressor speeds, reduced wear, less noise, higher efficiencies, and greater accessibility.

Also about that time, direct-connected gas engine-driven compressors were finding more and more application in the industry. While our company had not yet started building gas engines for that service, it did furnish numerous compressor cylinders for attachment to engines of different makes. Naturally, it preferred to sell complete units, and it is interesting to read in its publications of that period the list of weighty arguments as to why direct-connected gas engine-driven compressors just couldn't be right for that kind of work. Apparently, the wheels of progress were not stopped by those arguments. In the 1920's, the general trend towards direct-connected gas-engine drive became obvious and, falling in step, our company brought out its own duplex, horizontal gas engines.

For a number of years development proceeded along conventional lines. Improvements were made in compressor cylinders, valves, rod packing, etc., as well as in the engines—new and larger sizes were constructed. A radical departure from the accepted trend took place just prior to 1930 when our company introduced the first angle-design gas engine-driven compressors. It is interesting to note that the Seminole boom in Oklahoma was really responsible for that departure. This field came in in 1925 and was drilled so fast that within a year it was producing at the rate of 380,000 barrels a day. The ratio of gas to oil was relatively low and this, coupled with the intensive drilling campaign, soon reduced the gas pressure so much that the flow of many wells declined greatly or stopped. To correct this situation, air- or gas-lift pumping was adopted on a large scale.

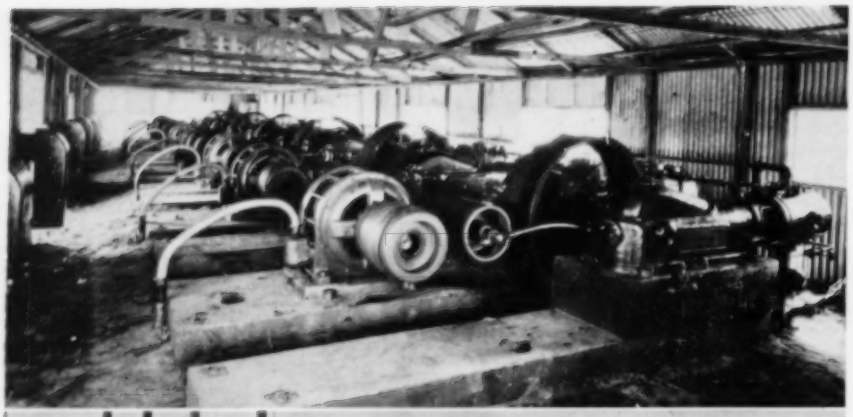
There was a crying demand in the field for gas compressors that were easy to set up and move, and to help meet it Ingersoll-Rand supplied hundreds of specially developed duplex compressors belt-driven by electric motors or, more often, by industrial gas engines. Since it didn't build such engines, and belt drive was troublesome, efforts were made to provide direct-connected, lightweight, and compact gas engine-driven machines. In 1928-29 the company brought out the first angle unit, with one power cylinder mounted vertically over each frame of the duplex compressor. During the following depression years the design was improved, and in 1932 the Class XVG—the original V-type, 4-cycle,

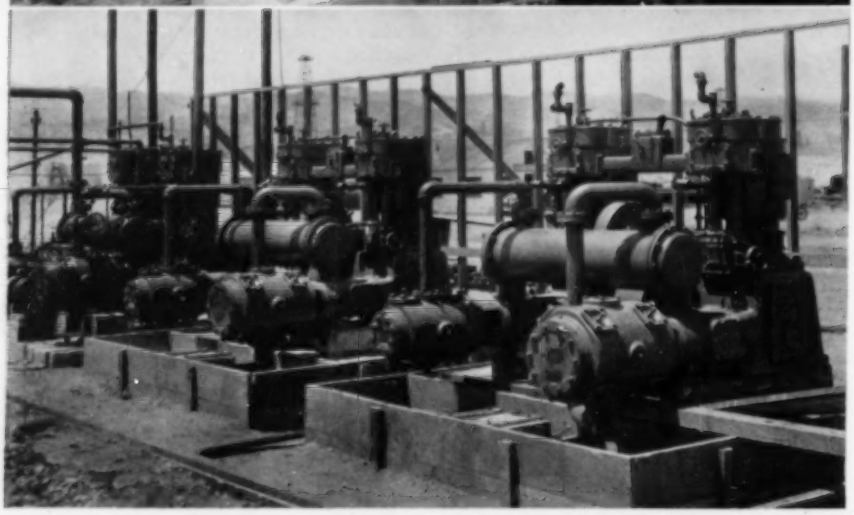




DIRECT-CONNECTED UNITS

Before Ingersoll-Rand developed its own gas engine-driven compressors, it furnished compression cylinders that were fitted on various makes of gas engines. Such combination units, consisting of Superior gas engines and I-R cylinders, are shown above in use in an Oklahoma natural-gasoline plant in 1925. That same year Ingersoll-Rand brought out its first gas-powered integrated compressor, the Type XG. It was a 4-corner machine with 4-cycle power cylinders at one end of its duplex frame, compression cylinders at the opposite end, and a central flywheel. At the left are six of these units in a Louisiana gasoline-extraction plant. The picture was taken in 1929.





SEMINOLE BELTED MACHINES AND XOG UNITS

A year after the Seminole, Okla., oil field was opened in 1926, it was producing 380,000 barrels a day—enough to fill a train of tank cars 17 miles long. The volume of gas in the oil reservoir was not large and, as its pressure dropped, hundreds of compressors were put to work injecting air or gas into the formation to lift the oil up the wells. Machines that could develop an initial "kickoff" pressure of 1000 psi. and maintain a flowing pressure of 500 psi. were required, and Ingersoll-Rand built the belt-driven XOB compressor to meet those conditions. Eight of them, operated by electric motors, are shown at the top. The difficulties and expense of transporting machinery in the Seminole Field emphasized the need for a compact, gas engine-driven, general-purpose oil-field compressor that could be readily trucked to a working location and moved elsewhere. This led to the introduction, in 1929, of the right-angle XOG unit with one vertical power cylinder for each horizontal compression cylinder. Three of these machines are pictured being set up in California.

angle, gas engine-driven machine—was introduced. Its advantages were soon recognized in the oil and gas industry and by manufacturers, and betterments made since then are well known to them.

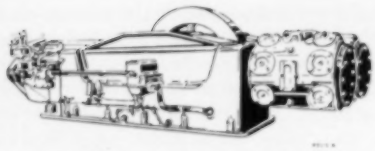
In tracing compressor development, it is noticeable that emphasis has always been put on valves, and each new one and its superior features have been discussed at length. Ceaseless efforts were made to improve efficiency and to provide a unit that would operate trouble-free. As a result, plate valves of a wide variety, sizes, materials, etc., have been produced since the original patent was bought in Europe, but research and development continue because the valve is the heart of the compressor.

Modern direct-connected gas engine-driven compressors now available to the natural-gasoline industry are a far cry from the first models. Great advances have been made in the design and construction of both compressor and engine. The units are much more compact, better balanced, and more efficient than those of former days and demand much less attention and maintenance. Oil cans have disappeared from the hands of operators. The fact that they are so reliable frequently leads to neglect and abuse, and repetition of the following well-known warnings is therefore justified:

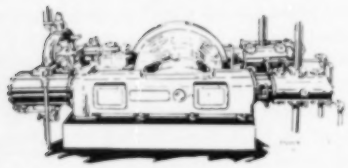
Protect your engine and compressors from dirt, particularly at the principal points of entry, namely: at the air and fuel-gas inlets to the engine and where the gas enters the compressor.

For combustion, a 300-hp., 4-cycle gas engine when loaded will consume about 40,000 cubic feet or 3000 pounds of air per hour. A modern 2-cycle engine will take even more, because additional air is needed for scavenging. Some dust and soot are always present in the atmosphere. No matter how small the amount of the contaminants, the cumulative effect over days, weeks, and months will be

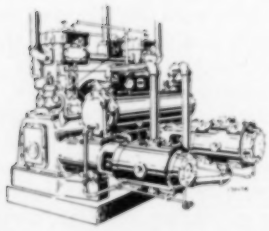
Belt-driven I-R Compressor



I-R Compressor cylinders



"XG"



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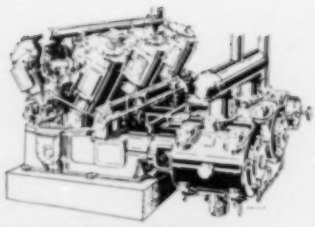
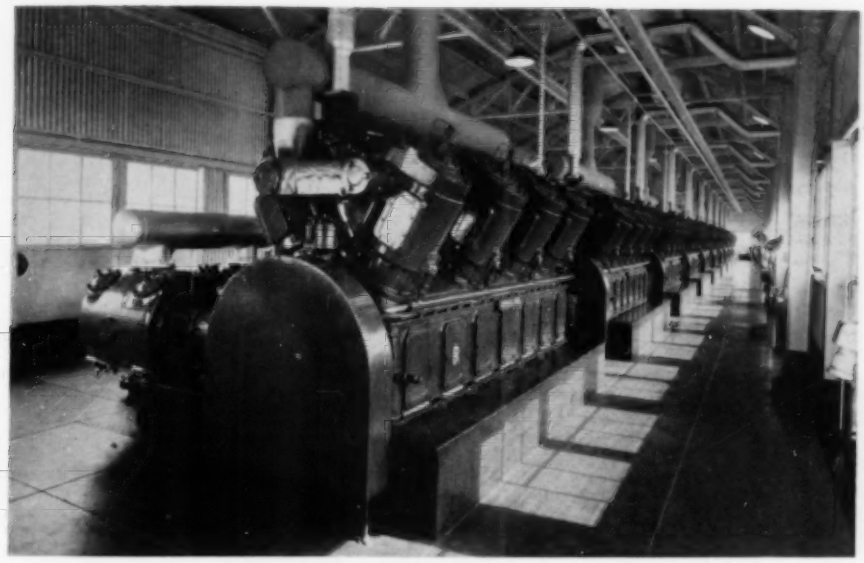


"XVG"

COMPRESSOR EVOLUTION

These sketches illustrate the changing trend in the design of Ingersoll-Rand oil- and gas-field compressors during the past three decades. Each succeeding step has packed added power and capacity into a smaller machine, with consequent reductions in weight, foundation requirements, and floor space per horsepower. Concurrently there has been an increase in operating efficiency, economy, and dependability.



THE XVG

In 1932 came the design that established the modern trend in oil- and gas-field compressors: V-type power cylinders and horizontal compression cylinders. Each pair of XVG power cylinders develops 75 hp., and units are available with up to eight cylinders, or 300 hp. Those shown are in a natural-gasoline plant in Texas.

serious when it is considered that 40,000 cubic feet of air goes through the engine cylinders every hour.

Remember also that dust, because of the turbulent effect built into most up-to-date engines, is thrown to the outside and onto the cylinder walls where the oily surface catches and holds it. The result is a grinding compound that causes wear on rings, pistons, and cylinders. Some of it also finds its way into the crankcase oil to set off a chain of additional harmful effects. To prevent these troubles, clean your air-inlet pipes carefully, install an efficient air filter, and service the latter regularly.

The precautions just listed are generally observed, but little if any attention is paid to the fuel gas and pipes. In consequence, dust, pipe scale, welding beads, etc., are fed into the engines with the fuel and may do far more serious damage and do it quicker than when open air-intake lines are used. Complaints have been received frequently, even in the case of new installations, that the engines wouldn't carry the load after a few days of operation. Upon inspection, the screens in the fuel lines to the mixing valves were found to be clogged with dirt, causing the units to be starved for fuel gas. How much dirt had meanwhile passed through the screens and was grinding away at the vital parts of the engines was hard to tell. Again, thoroughly clean all gas-inlet pipes and, if you are not absolutely certain that the gas is clean, put a fuel-gas filter in the line. It costs comparatively little— in fact much less than it would to replace worn cylinders, pistons, and rings.

Abnormal amounts of dirt fed through compressor cylinders, particularly during the starting-up period, is another common and sorry occurrence. There have been instances where literally wheelbarrowfuls have been removed from the gas-inlet pipes of the cylinders and from the inlet passages in the cylinders themselves, and that after only a few hours' operation. The result: broken valves and scored rods, rod packing, cylinders, pistons, and rings—in short, more wear than should normally be expected after several years of service.

The importance of keeping the power-cylinder jackets free from deposits and scale is not always appreciated. One often hears the argument that a layer of scale only 1/16 inch thick certainly cannot be the cause of the trouble experienced. Actually, a much thinner deposit can be exceedingly harmful. Some years ago, in an article on the effect of scale, *Diesel Power and Diesel Transportation* stated that the heat transfer of a 1/16-inch layer of calcium-carbonate scale is equivalent to that of 4 1/4 inches of cast iron, whereas the heat transfer of silicate scale of the same thickness is equivalent to that of 14 7/8 inches of cast iron. The writer does not know how accurate these figures are, but the picture presented explains many things that have happened in the past and stresses the urgency of avoiding scale deposits in cylinder jackets.

Only the common ills from the list of those usually found in instruction books have been singled out because, with the present shortage and cost of labor, the precautionary rules against them are frequently neglected. Actually, this is a shortsighted procedure in view of the fact that time, labor, and expense involved in correcting the resultant troubles far outweigh those required to guard against them in the first place.

Don't get annoyed when manufacturers keep on harping about these things. They take pride in their equipment and aim to build the best possible under existing conditions. They are anxious to have the machines perform well and to satisfy their customers. It hurts to see the equipment abused, especially in the first hours or days of operation. Compressors and engines of today are superior to those of the past, but it is up to the user to get full worth out of them.

THE KVG

An outgrowth of the XVG and generally similar to it in basic design, the KVG is a more powerful, higher-capacity compressor, embodying every feature that experience has proved to be desirable. Each pair of power cylinders develops 200 hp., and machines are built in sizes from 600 to 1200 hp. Pictured are seven 1000-hp. machines in a Gulf Coast natural-gasoline plant.

Foundry Birthday

The H. P. Deuscher Company, in Hamilton, Ohio, Has Been Serving Industry for 70 Years.

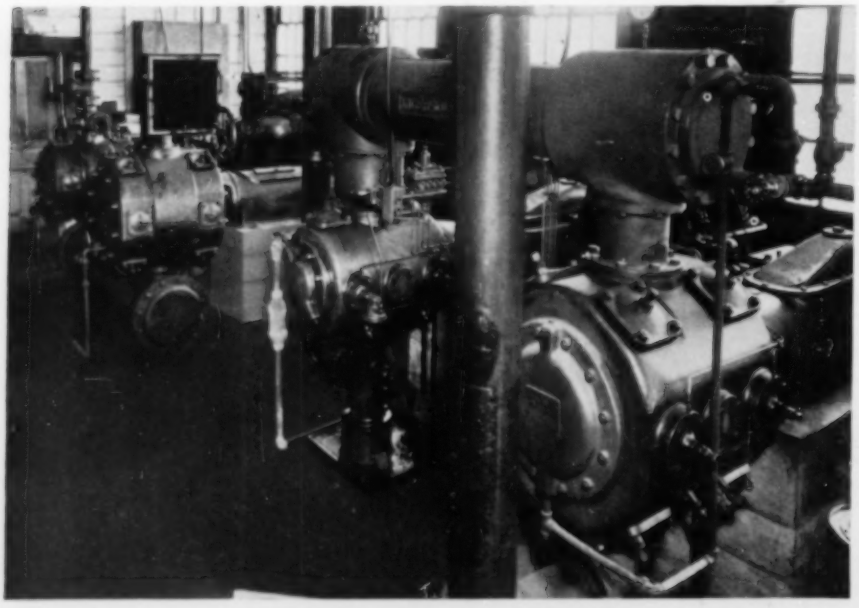
PRIZE-WINNING FLOAT IN PARADE OF PROGRESS

The Deuscher Company actively supports all community enterprises, believing that anything that helps Hamilton helps it.

NO ONE knows when the casting of metals began, but it was many centuries ago. There is reason to believe that copper and gold were the first metals cast. Certainly, in those early times men had learned little or nothing about extracting iron from its ores. Nowadays, iron is our most serviceable metal, and in the form of gray-iron castings enters into countless articles that everybody uses.

In 1947, the American foundry industry produced a total of 12,540,000 castings of this kind, and these represented 78 percent of all the metal castings made by them in that period. There are some 2500 gray-iron foundries in the United States, most of them rather small and serving limited areas because it is expensive to ship their heavy products far.

One of these establishments, The H. P. Deuscher Company of Hamilton, Ohio, recently reached its seventieth year and, in the opinion of its management, has gained the right to reminisce a bit. Accordingly, it issued a descriptive booklet to acquaint townspeople with its business. "The public," it commented, "knows little about the method and difficulty of producing gray iron castings, and yet it is one of the most important industrial activities. Gray iron foundries are the works behind the industrial scene, the source of many of the parts from which others manufacture goods that are nationally advertised and sold to homes, offices, and businesses. Consumers rarely buy castings as such, but purchase countless articles of which castings are indispensable parts."



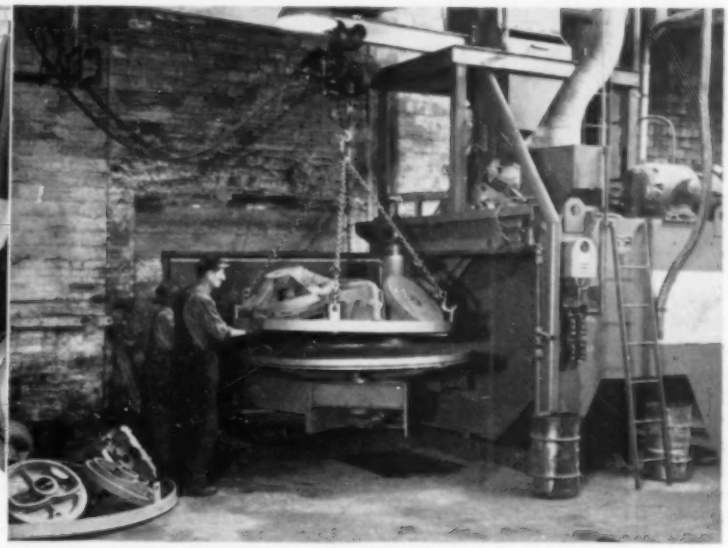
COMPRESSED-AIR PLANT

Compressed air, which is indispensable to foundry operations, is supplied by these two synchronous motor-driven compressors. They have a combined capacity of approximately 1200 cfm. In addition to the uses pictured on the opposite page, air performs numerous other services such as operating molding machines through the medium of pneumatic cylinders. The jolting motion they impart to the machines compacts the sand in the molds.

The Deuscher Company was established in 1878 when Henry Deuscher bought control of the Variety Iron Works which had been operating in Hamilton for some years. The founder was brought to America by his parents from Baden, Germany, in 1829. The family resided in Lancaster, Pa., until 1836, then migrated to Trenton, near Hamilton. In 1862, Mr. Deuscher recruited and captained a company of soldiers in the Civil War. Following his discharge, he returned to Trenton and engaged in farming until he entered the foundry business. The company was incorporated in 1888, with the Deuscher family owning all the shares. Until his death in 1903, Mr. Deuscher directed its affairs and laid the groundwork on which those that followed him have continued to build.

The Variety Iron Works had been making castings for the Fashion school desk and for some implements. When he acquired it, the new owner, influenced perhaps by his farm training, engaged in the manufacture and sale of a diversified line of implements, including the Barbour corn drill, McColm soil pulverizer, Victor churn, Favorite churn, Hamilton check-row corn planter, horse-drawn hayrakes, and disk folding and lever harrows. Some of them were sold throughout the nation. In 1893 the Cincinnati Heating & Ventilating Company was purchased, and Deuscher's hot-air furnace was added to the line of products.

In 1910, fire completely destroyed the Deuscher plant, and this brought a change in company policy. New buildings were constructed with the idea of specializing in gray-iron castings, and there has been no change since then. Current output consists of medium-light gray-iron castings that enter into laundry equipment, electric motors, baking machinery, roadbuilding equipment, bor-



TYPICAL USES OF AIR POWER

The picture at the left shows pneumatic chipping hammers being used to remove excess metal from castings. Above, an Ingersoll-Rand air-motor hoist that travels on an overhead boom is seen loading castings on a table which will be swung into the American Wheelabrator sandblasting cabinet at the right. This time-saving method of handling a tray of castings at a time was developed by Deuscher technicians.

ing mills, radial dials, casters, water and sewage-disposal pumps, lathes, elevators, paper punches, etc. Some castings are made one or two at a time, or maybe a dozen; others by the hundreds or thousands. Many of the same parts have been in production for 38 years, and the average length of time the firm has served its customers is 21 years. Although castings are supplied to comparatively few concerns, the pieces ordered are so varied that 160,000 patterns and core boxes are kept on hand.

In line with usual foundry practice, the metal is melted in a cupola, which is charged with alternate layers of pig iron and large-size coke. A Deuscher-developed semiautomatic charging process facilitates this operation. Molten metal is drawn off into ladles and transported by monorail or crane to be poured into prepared molds.

As the Deuscher booklet points out, casting is a laborious and technical procedure, but it accomplishes results that can be obtained in no other way. The process of forming objects by the solidification of molten metal within connected-mold cavities is both convenient and economical. "Only the problem of achieving necessary details in the molds," it is stated, "can put a limit on the intricacy of castings. Looks are important in castings made for decorative purposes; others are parts of machinery where strength is of prime consideration; while still others require a combination of appearance and strength.

"The procedure is to make molds by impressing a design into treated sand. In this mold are placed sand cores, already treated and baked, to keep metal out of that part where none is needed in the finished casting. After the molds have been made and the metal poured and allowed to cool, mold and casting are separated. From there the casting goes to the cleaning and chipping department before it is converted into a wheel, lever, bar, or any of the other thousands of items that are needed to equip today's industry with machinery.

"All this may sound simple, but it must be remembered that the process involves various intricate operations in sand of just the right consistency to produce a clean casting. It involves the correct preparation of sand and precise placing of cores so that the casting will come out as nearly perfect as possible in shape, size, surface finish, and quality of metal. Sand molds of the required sizes and shapes are made within frames of wood or steel and called flasks. The sand is mixed with the smallest amount of clay that will form a good bond, since the mixture must remain permeable enough to release gases from the molten metal. If this is not done, strains, stresses, and other defects in the metal may result.

"A core is a body of sand or other refractory material that is prepared separately and put in place in the mold during or following its construction. The internal surfaces of most castings thus are formed by cores. Not all sands are the same; different sizes and shapes of grains are suitable for different purposes. Binders for cores are oil, water-soluble pitch and resin, depending upon the use to which the core is to be put. Sand mixtures must have enough strength to permit their being handled on the way to and from the baking ovens."

In common with all establishments of its kind, the Deuscher foundry uses compressed air extensively. About 95 percent of the molds are prepared on machines in which the sand is consolidated by a jolting motion imparted by pneumatic cylinders. These are of various sizes, with a combined capacity of twelve million pounds of castings per year. Air-operated hoists lift and transfer castings and materials at several places in the plant. Following their removal from molds, castings are cleaned with pneumatic chipping hammers, grinders, wire brushes, etc. All the hoists and tools are of Ingersoll-Rand make, and air power is supplied by two I-R direct-connected, synchronous motor-driven compressors having a combined capacity of approximately 1200 cfm.

The Deuscher organization takes pride in two things: First, it aims to produce the best possible product. Second, it wholeheartedly supports all community undertakings in Hamilton, which is a thriving manufacturing center, in the belief that "the way to have a better city is to work at it, not spasmodically but continuously, year after year."

Although not the largest business of its kind even in its own city, it is a close-knit organization in which management and employees work harmoniously. In the past 30 years not an hour's production time has been lost through strikes or disagreements. The foundry normally employs 140 persons, and during the war years it had around 50 additional workers. Officers are: Clarence D. Ehresman, president; Herbert O. Ehresman, vice-president; Earl H. Thompson, secretary-treasurer.

Grouting with Pneumatic Equipment

GROUTING, forcing liquid cement mixtures into cavities and spaces, may be done at either high or low pressure, depending upon the thickness or consistency of the material and upon the size of the openings to be filled. Low-pressure grouting is usually done with pneumatic machines, this being particularly true on construction jobs where compressed air is always available. Among the many machines introduced for this work is a pneumatic placer designed and produced by Robert S. Mayo, a civil engineer of Lancaster, Pa.

The Mayo grouter is built to operate at a pressure in the neighborhood of 100 psi. and consists essentially of a pressure chamber fitted with valves and pipes for the admission of compressed air and the discharge of grout. A charge not exceeding 3½ cubic feet in volume is placed in the machine and the door is closed. The shooting valve is then opened to seal the door and put pressure on top of the grout. That done, the grout valve is opened and the mixture discharged. In reverse order, the respective valves are manipulated to release the pressure and open the door.

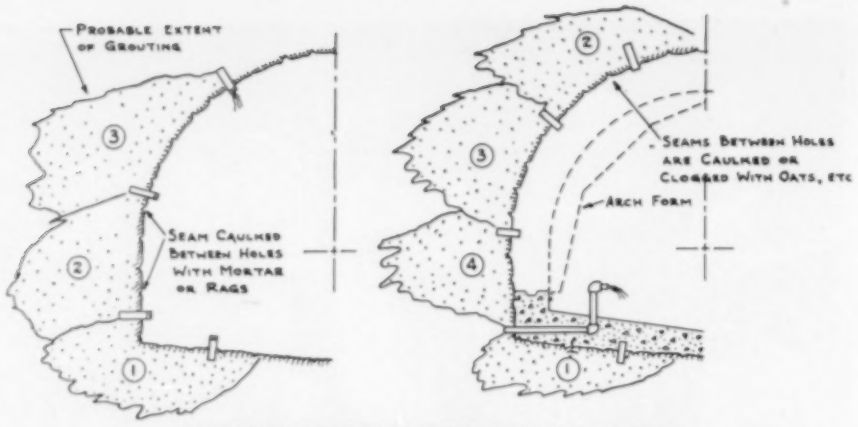
Either neat or sand grout may be used in the machine. The former mixture is in the ratio of about 6 gallons of water to one bag of cement, while the other is in the approximate ratio of one bag of cement and one cubic foot of sand to 10 gallons of water. In either case, the amount of water can be varied to provide a mix with a consistency ranging from thick cream to the stiffest the machine can handle effectually.

Although intended primarily for applying grout, the device may be utilized as a mixer. Water placed in the pressure chamber is made to "boil" vigorously by slightly opening the agitator valve. The cement is then poured in slowly, followed by the sand. If the batch cannot be discharged immediately, the solids can be prevented from separating by continuing to agitate the mass.

There are many applications for grout in construction work. Dam foundations, for instance, are generally grouted to seal channels that might cause leakage when the reservoir behind the barrier is filled. This operation usually involves forcing grout to refusal through holes drilled from the surface to bedrock to form a cutoff or curtain the entire length of the dam. Badly fissured bridge foundations may be similarly solidified. Tunnel walls are grouted to make them impervious to ground water before the concrete lining is placed, while spaces back of lagging may be filled with loose rock or gravel and consolidated with grout.

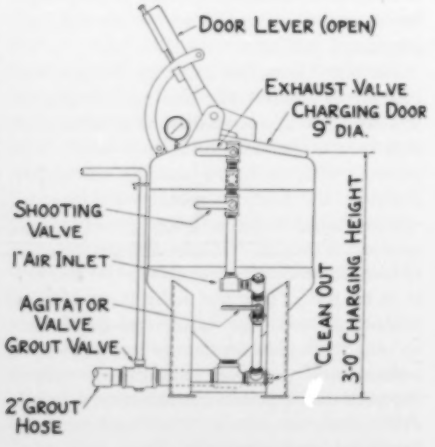
To prevent the ground from settling in the case of shield-driven tunnels it is the general practice to apply pea gravel around the advancing shield and to bind it into a homogeneous mass with grout. Bores in soft formations are generally made oversize to facilitate erection and alignment of the primary lining, and the space between walls and liners must be promptly filled to prevent movement of the ground. Pea gravel cemented with grout serves this purpose well and can be handled by the Mayo machine, with a few minor changes.

Other operations for which the unit is suitable include the raising of sunken concrete slabs and pavements by forcing cement or lime grout under them; grouting dry-laid stone walls to make them well-nigh as strong as concrete; consolidating old bridge piers that are faced with ashlar and filled with loose rock, as well as brick sewers to prolong their useful life; and grouting railroad subgrades to lessen the time normally spent in maintaining roadbeds.



GROUTING STABLE AND UNSTABLE ROCK

In "good" ground (left) holes are drilled at intervals along the seams and then pipes are cemented into them. Between holes the seams are caulked. Grouting starts at the lowermost pipe and progresses upward, the water being forced out of the highest one which is grouted last. In fractured ground (right) the procedure is reversed, the work being done from the top down.



MAYO PNEUMATIC GROUTER

Machine (left) is pictured at work in a small tunnel in Washington. The drawing shows construction details.

Aluminum in the Role of Structural Material

THE romantic story of the metal aluminum is still unfolding. The latest chapter is a report from Canada that the once rare and costly material is being used to fabricate a highway bridge more than 500 feet long and also to form the main members of a traveling crane with a lifting capacity of 15 tons. Thus, aluminum is gradually assuming the role of structural material that its manufacturers envisioned for it.

Until about 60 years ago, aluminum represented one of nature's paradoxes. Although the most abundant metallic element, it could be extracted only at great expense. It makes up about 8 percent of the earth's crust, but is always found tightly locked in combination with other elements. Tremendous amounts of electricity are required to break the bonds. Thus, while every clay bank and most common rocks are actually ores of aluminum, only the mineral bauxite now yields it in commercial quantities. Nevertheless, scientific research and industrial ingenuity have teamed up to produce it at a cost that permits it to compete with some other metals that can be obtained by comparatively simple metallurgical processes.

Unlike most common metals, aluminum received an early boost from royalty. Following its initial isolation by the Danish scientist Hans Oersted in 1825, Frederick Woehler of Germany succeeded in making enough of it by 1845 to determine some of its physical properties. Upon hearing that it was light and malleable, Napoleon III had the idea that its use in military equipment might increase the mobility of his army. Forthwith, he commissioned the French chemist, Henri Deville, to find a way to produce aluminum on a large scale and at low cost. The metal was then selling at more than $500 a pound.

By altering the earlier process, Deville brought the price down to $34 a pound in 1856 and halved that figure in 1859, when world output reached 2 tons. He wasn't able to help Napoleon, but he did make enough aluminum for scientists to play with and to bring about limited commercial applications.

Attention thus drawn to the new metal led to the development of the present method of obtaining aluminum by electrolysis from a solution of alumina in molten cryolite. The process was worked out simultaneously but independently by two 22-year-old youths on opposite sides of the Atlantic—Charles M. Hall in America and P. L. T. Heroult in France. Both were fortunate enough to interest financial backers. Six Pittsburgh men organized the Pittsburgh Reduction Company and began making aluminum on Thanksgiving Day, 1888. The firm name was changed to Aluminum Company of America about twenty years later. A group of Swiss businessmen formed the Aluminum Industrie Aktiengesellschaft to exploit Heroult's process.

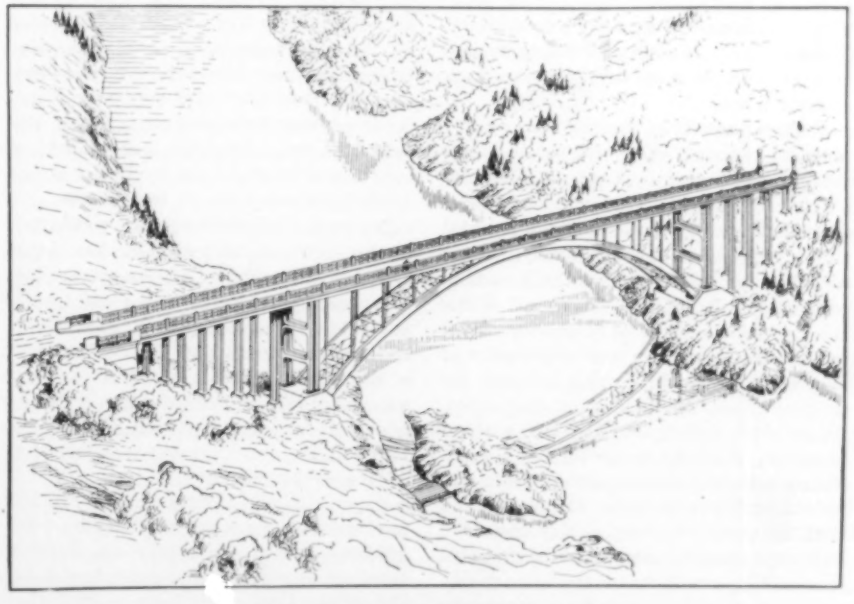
From these beginnings the manufacture and application of aluminum have grown steadily. In 1943, at the peak of our war production when the metal was in demand for airplanes and other military equipment, United States output of primary aluminum reached 920,000 tons and of secondary aluminum (from scrap) 314,000 tons. The price held steady at fifteen cents a pound.

Canada's aluminum industry is centered at Arvida, in Quebec Province, where the great 1,200,000-hp. Shipshaw hydroelectric plant was secretly built during the war to increase the production of that vital metal. It is only natural that the people of Arvida should be aluminum-conscious and promote its use in every possible way. Consequently, it is not surprising that the first aluminum bridge is being erected there. It will cross the Saguenay River between Arvida and Shipshaw. The Arvida City Council approved its construction last February, and a contract was awarded to the Dominion Bridge Company.

The structure will have a main arch span of 290 feet over the stream proper, and at each end there will be five approach spans with a total length of 504 feet. The roadway will be 24 feet wide, with a 4-foot sidewalk on each side. All structural members will be made of aluminum alloy designated as Alcan 26-ST. Precast concrete slabs will be laid on the deck and sidewalks, and their reinforcing steel will be welded together in the field. Grouting will join the slabs to form continuous sections between expansion joints and a layer or wearing surface of asphalt will complete the roadway. Railings and approach pylons at the south entrance will be of aluminum.

Among the economic considerations that influenced the engineers to specify aluminum is the fact that the bridge framework will weigh only 400,000 pounds, or approximately half as much as would a similar steel structure. This weight saving will reduce freight charges, simplify foundation work, and facilitate erection. As the metal will not have to be painted to protect it from corrosion, maintenance cost will be low.

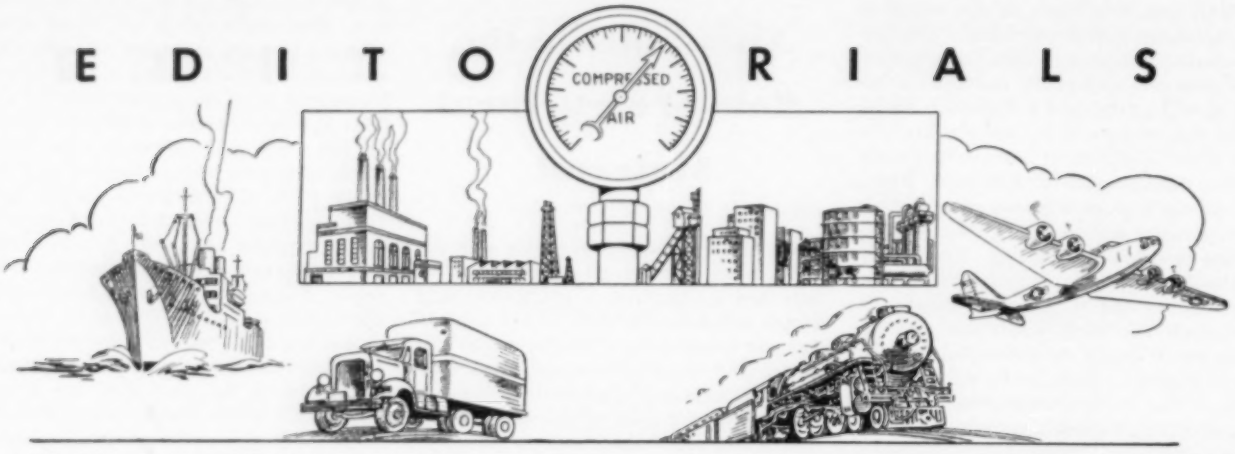
The aluminum crane, which was also fabricated by the Dominion Bridge Company, has been placed in the rod mill of the Aluminum Company of Canada, at Arvida. Its 97-foot girders are made of high-strength aluminum-alloy channels, angles, and plates which are joined by aluminum-alloy rivets and bolts. Complete, the crane weighs 51,735 pounds, as compared to 94,000 pounds if steel had been used. Consequently, it can be operated by a motor of 30 percent less power than would otherwise be needed. Supporting steelwork also is lighter than usual.



ALUMINUM HIGHWAY BRIDGE

Perspective drawing of the lightweight arch-type structure being built across the Saguenay River in the Canadian Province of Quebec to link the communities of Arvida and Shipshaw. It will be 504 feet long and carry a roadway 24 feet wide, as well as two 4-foot sidewalks. The framework will weigh about half as much as it would if made of steel. The bridge is being erected by the Dominion Bridge Company under a contract let by the City of Arvida.

EDITORIALS



GASOLINE-TAX DIVERSION

TAXES levied on gasoline sales by the various states are ostensibly for expenditure on highway improvements. Many states have kept faith with this arrangement, but others have regularly or occasionally diverted some of these funds for other purposes. This practice has been followed for many years, but is fortunately being gradually abandoned. The American Road Builders Association, which has spearheaded the drive against diversion, reports that the present trend is away from diversion.

Nineteen states have passed constitutional amendments prohibiting the spending of these funds for other than highway purposes, and ten additional states have similar legislation pending. This is as it should be. The gasoline tax is, in effect, a toll charge paid by motorists for the use of roads and streets. It is a special levy for a specific purpose. The diversion of money so collected amounts to a second tax on motorists because virtually all of them also pay general taxes.

Even those who do not own automobiles should favor strict adherence to the nondiversion policy. Adults and children alike ride buses and are consequently vitally interested in arterial thoroughfares that permit traffic to move rapidly and safely and without undue congestion. Because a large part of the things we consume is transported in trucks, the condition and ampleness of highways affects the price we pay for them. Good roads attract industries, promote the free flow of commerce, stimulate all lines of local business associated with automotive equipment, and reduce accident hazards. It is estimated that 90 cents of every dollar spent on highways goes for wages and thus helps to stabilize employment.

About 40 million automotive vehicles are in service in the country, or approximately one for every three and one-half persons. They have come to be the backbone of our local transportation systems, as is evidenced by the fact that factory wheels stop and business stagnates when emergency conditions occasionally prevent cars from moving. Once a luxury, the automobile is the average man's necessity today.

It is important right now that existing roads be improved and new ones built. Low returns from gasoline taxes during the depression years necessarily curtailed highway spending. Then came the war period, during which roads were heavily pounded and could not be adequately maintained. As a result there is a heavy backlog of construction that is urgently needed to enable the nation's highway system to handle increasing traffic safely and efficiently.

THE CONTRACT SYSTEM

OUR free-enterprise system of constructing public works by the contract method needs little defense. It has worked so well and bred so few scandals that it has come to be regarded as the best way of spending the taxpayers' dollars. Even the governmental agencies that plan and supervise large-scale construction programs rarely dissent from this viewpoint, and it is seldom that one of them elects to do the actual work involved with its own forces.

By way of bolstering public confidence in the contract method, The Associated General Contractors of America, Inc., has recently set forth its advantages in a booklet prepared for general distribution. It points out, first of all, that a general contractor posts a bond to guarantee completion of a given job for a stipulated sum and within a designated time, and that the work shall be of a specified quality.

Competitive bidding assures efficient performance, because it is only by being efficient that a contractor can survive. Irresponsible firms are soon weeded out. Established concerns have earned their stability the hard way. Experience is their greatest asset and likewise surety that they will carry out every contract with fidelity. In addition to this know-how, they are well-quipped, well-staffed, and resourceful enough to adapt or improve upon conventional methods or to devise new ones to meet unusual situations as they arise.

Because no contractor can bid on a job intelligently unless he is fully informed about it, his preliminary work includes careful planning that prevents mistakes and insures a finished structure that will adequately serve the purpose for which it was built. The contract method centralizes responsibility and fully protects the public interest. It makes sure that recognized standards of safety will be adhered to and that equipment and supplies will be obtained through normal channels.

Private firms have demonstrated that they can construct all types of public works faster, better, and at lower cost than they can be built by any other method. Their accomplishments during the recent war speak for themselves. More than 49 billion dollars worth of construction was completed under contracts at unprecedented speeds.

Actual comparisons of the efficiency of building highways under contract and by force account were made by the U.S. Public Roads Administration during the depression years of 1933-34. Fifty-three projects, involving various types of construction and located in 46 states, were carried out by highway-organization forces after they had been advertised and bid on in the regular way. No advance information was given as to the particular jobs that were to be selected for test. The aggregate cost of doing the work was $3,942,879, or $593,126 higher than the combined bid prices of contracting firms.

The Public Roads Administration, Army Corps of Engineers, and the Bureau of Reclamation, which are the principal sponsors of large-scale Federal engineering projects, long ago adopted the policy of carrying them out under contract rather than with their own forces. This decision permits them to do work on a large scale with relatively small supervisory staffs and has eliminated the necessity of building up huge and costly inventories of equipment.

Moles' Awards to Oakes and Scott

LUTHER S. OAKES

THE annual awards by The Moles', New York organization of tunnel drivers and heavy-construction men, for outstanding achievements in their fields will this year go to Luther S. Oakes of Minneapolis, Minn., and Capt. Thomas A. Scott of New York City. Bronze plaques and award citations will be presented by J. Rich Steers, Moles' president, at a dinner meeting in New York on February 9.

Mr. Oakes, who will receive the nonmember award, has been president of Winston Bros. Company for 28 years. Born in Vermont in 1877, he was graduated from Dartmouth College in 1899 and Thayer School of Engineering in 1900. He went to work for the Northern Pacific Railway Company as a surveyor in 1900 and rose to division engineer. He joined Winston in 1907 and served as a field superintendent on railroad construction in Montana and Washington during the next four years.

He was made a member of the concern in 1911, a director in 1913, a vice-president in 1920, and president in 1921. He is an officer and director in several subsidiaries of Winston Bros. Company, as well as a member of the American Society of Civil Engineers and of the Associated General Contractors of America. His organization is a pioneer in the field of railroad building in the Northwest and has specialized in dam construction, flood control, and drainage work throughout North and South America.

Captain Scott, recipient of the member award, is chairman of the board of Merritt-Chapman & Scott Corporation, which he formed in 1922 by merging T. A. Scott Corporation with Merritt & Chapman Derrick & Wrecking Company. The Scott company was founded by his father, Thomas Albertson Scott, who was an outstanding diver, salvage officer, and construction engineer. He directed the extraordinary work involved in the building of the Race Rock Lighthouse off New London, Conn., and was responsible for the design and construction of the first dock authorized by the New York Dock Department and for some of the work on the underwater foundations of Brooklyn Bridge.

Captain Scott was born in Connecticut in 1877. Following his graduation from Mystic Valley Institute, he was a blacksmith's helper for a time, then went to sea, where he rose from sailor to captain, salvage officer, and manager. He became president of the T. A. Scott Corporation in 1903 and supervised its activities during the ensuing fourteen years, specializing in salvage work and marine construction from New York to Maine. Under his leadership, the firm became one of the nation's leading salvage organizations.

He was commissioned a lieutenant commander in the U. S. Navy during World War I and directed salvage operations, both naval and commercial, in American and European waters. Upon his return to civilian life in 1918 he was appointed a commissioner of the U. S. Shipping Board. After the merger of the Scott and Merritt & Chapman concerns, the new firm continued in the fields of salvage, marine construction, heavy hoisting, and literage, as well as in subaqueous foundation work. In 1926 it also entered the business of general contracting, and now operates throughout the world with general offices in New York and branches in New London; Cleveland, Ohio; Norfolk, Va.; Key West, Fla.; and Jamaica, B.W.I.

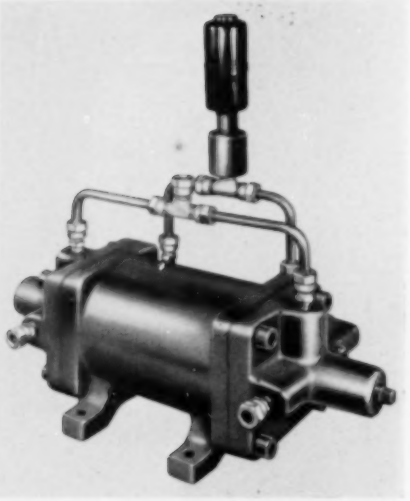
During World War II, the corporation conducted salvage work under contract with the U. S. Navy that resulted in the restoration of 700,000 tons of shipping valued, with cargoes, at $655,000,000. These activities extended from the Aleutians to the west coast of South America and along the east coast of North and South America into the mid-Atlantic Ocean. One of the outstanding jobs was the righting, raising, and floating of the French luxury liner *Normandie* after she caught fire and capsized at Pier 88 in New York Harbor on February 9, 1942. For his direction of those salvage operations Captain Scott received the Medal of Merit, the nation's highest civilian award. In addition to its wartime marine work, the corporation built the Naval Air Station at Quonset Point, R.I., the Advance Base Depot at Davisville, R.I., tank farms at Reykjavik, Iceland, and air bases at Newfoundland and at Londonderry, Ireland.

CAPT. THOMAS A. SCOTT

Postwar activities have included the construction of the first streptomycin plants for Merck & Company at Elkton, Va., and Rahway, N. J., integrated pulp and paper mills for the Hudson Pulp & Paper Company at Palatka, Fla., and for the Alabama Pulp & Paper Company at Cantonment, Fla., eleven piers and berthing facilities for the U. S. Navy at Green Cove Springs, Fla., the substructure of a bridge across the Mississippi River at Memphis, Tenn., coal unloading docks and facilities for the Baltimore & Ohio Railroad at Lorain, Ohio, and the world's largest veterans' hospital at Peekskill, N. Y. Currently underway are the Potomac River Bridge at Washington, D. C., the Pasadena Tunnel at Houston, Texas, new steel fabricating facilities for the National Tube Company at Lorain, Ohio, and permanent housing for workers in the atomic-energy plant at Oak Ridge, Tenn.

A section of a business street in Akron, Ohio, has been resurfaced with a "hot-mix" asphalt aggregate and powdered synthetic rubber. It is reported that pavements containing rubber were laid in England and Holland some years ago and have shown desirable qualities, including resilience, long wear, and resistance to cracking in cold weather. One such road in The Netherlands, over which Hitler's invasion troops streamed in 1940, withstood the heavy traffic well. Upon inspecting it during a postwar trip abroad, P. W. Litchfield, board chairman of the Goodyear Tire & Rubber Company, introduced the idea in Akron. Short stretches of two streets were paved with the combination a year ago. Proving satisfactory, rubber was specified for the larger area lately surfaced.

Air-Powered Hydraulic Press



AT WORK

Picture at the left shows five of a battery of seven Hydrolairs in the plant of the Belden Manufacturing Company. They are molding rubber sleeves on plug-board cords and are also used to mold one-piece rubber plugs around electric-power cords. Heads of presses are adjustable, and working pressure is set by regulating an air valve. The Power-petuator (above) is in the base of the machines, which are of the floor type, and mounted at the rear of bench models.

COMPRESSED air from a shop line is all the power that is needed to operate a new hydraulic press—the Hydrol-air—announced by Elmes Engineering Works for operations requiring not more than 50 tons pressure. The feature of the machine is the Power-petuator or intensifier, a self-contained unit that automatically provides a continuous full-pressure stroke and maintains any preset ram pressure.

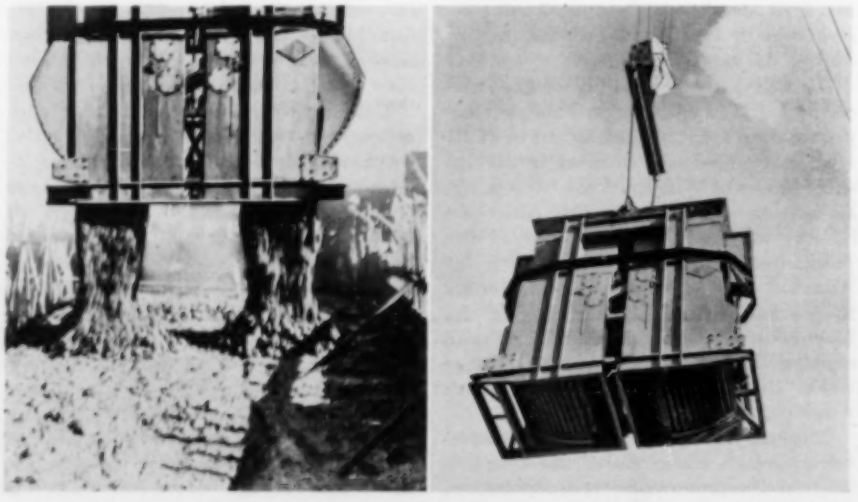
With the control lever in "closing" position, air at 90 pounds pressure is introduced above the liquid level in a reservoir to raise the platen; reversing the lever, diverts the shop air into the Power-petuator where its effective force for press compression is multiplied many times. Though compressed air is the motivating power, the machine is, nevertheless, in the hydraulic class because both ram movement and pressure are induced by noncompressible oil.

Presses are equipped with both electrically heated and water-cooled plates and with thermostatic control. Or, when both sets of plates are of the steam-heated type, steam or chilling water may be put in either one to make, in effect, a double-deck press. Applications of the Hydrolair are numerous, and include molding plastics and rubber; laminating impregnated paper, cloth, and glass; sealing photographs and identification cards, etc., between sheets of transparent plastic; gluing, repetitive test work, and many other similar jobs.

Concrete-Pouring Bucket with Air-Controlled Gates

AS THE result of a change in specifications made by U. S. Army Engineers, Blaw-Knox Company now has in production a new type of bucket for pouring mass concrete on large construction projects. It is rectangular in form, has a full bottom opening with air-operated roller gates that permit placing all or any part of the contents at a given point, and is handled by cableway. Air at a pressure of 100 psi. serves to control the gates and is applied through a hose connection that can be made and broken with ease.

As the requirements prohibit the use of 8-cubic-yard buckets that dump their load in one pile, larger sizes of the new design are made by coupling together two 3- or 4-cubic-yard units with individual discharge. Single-compartment buckets range in capacity from 2 to 4 cubic yards. Tests have proved that the pneumatic gate functions with facility and that the concrete, regardless of the kind of mix, is discharged quickly and completely.

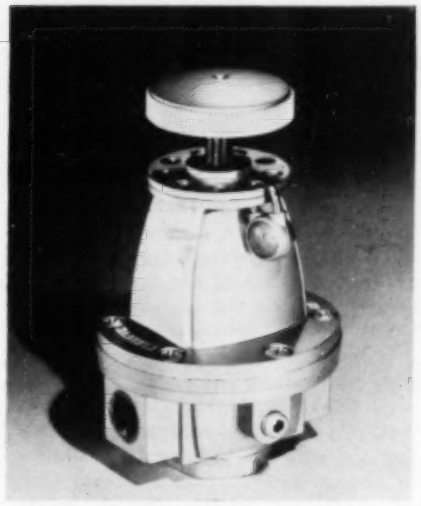


TEST BUCKET

The original 2-compartment, 8-cubic-yard bucket that demonstrated the suitability of the type for pouring mass concrete. The pictures show the bucket suspended from a cableway exposing the air-operated roller gates and discharging its load in two 4-cubic-yard piles. The new design is fundamentally the same except for a few structural improvements.

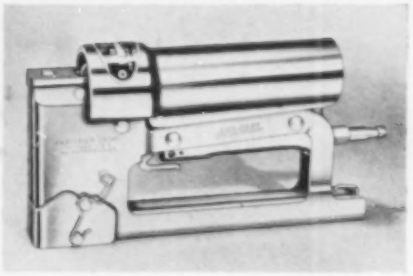
Industrial Notes

Two new pressure regulators for specific applications on compressed-air supply lines have been announced by Hannifin Corporation. Designated as series PRD and LRD, both are of the recently introduced Air Warden Type. They are available in ⅜- and ½-inch sizes for primary pressures to 150 psi. and secondary pressures from 5 to 125 psi. One of the features of these regulators is a free-floating valve stem which makes it possible to back off or reduce the delivered pressure under dead-end conditions by turning an adjusting knob. This results in air savings in the case of pneumatic cylinders where it may be desirable to lower the applied pressure without exhausting the cylinder. Series PRD is provided with a flange for panel mounting, the knob extending through to the front of the instrument board while the valve remains back of it for convenience in making pipe connections. LRD regulators are for use where it is desirable to lock the adjusting knob against unauthorized change in pressure setting. The lower disk of this type, which carries four holes, is stationary, while the upper one, which turns with the knob, provides 36 possible locking combinations.



Studies of Wyoming bentonite by a chemist of the U. S. Geological Survey have brought to light some interesting facts about the mineral, a bedded plastic clay that swells greatly upon wetting. In the form of a slurry or mud it is used extensively in the petroleum industry to seal the walls of oil wells against seepage. Today, only the green bentonite which lies near the surface is mined, while the blue-gray subsurface material is discarded. Both are alike in chemical composition and iron content; but where the former has been oxidized, the latter is in the ferrous or unoxidized state in which it is deficient in colloidal properties. The findings of the Survey are significant, for tests have revealed that ten months' exposure to air will oxidize the iron content of the blue-gray bentonite to a point where it will have the same characteristics—expand as much—as the green now being mined.

For operations requiring continuous stapling, there is now available a pneumatic tool weighing 2¼ pounds that is said to do fast, effortless work. It is called the Duo-Fast Air Tacker and is designed to drive medium- or heavy-gauge wire staples from 5/32 to ⅜ inch long in regular or narrow crown widths, as well as models with extended front lips for use in recessed areas or with cut-out jaws for fastening low-voltage electric wire. The standard unit is actuated by pressing a pistol-type trigger and may be equipped for automatic control. Air at a pressure of 80 to 90 psi., or sufficient to compress a spring—the actual driving force—is required to operate the tool. Where a shop is not piped for air, a ½-hp. compressor with a 30-gallon air receiver will supply enough power for two tackers, but multiple installations necessitate the use of a larger machine with a 60-gallon reserve tank. The air is admitted through a ¼-inch hose attached to a nipple at the back of the tool and compresses the spring through the medium of a pneumatic cylinder. With the staple pusher at the bottom loaded, the operator holds the front end of the unit tight against the work and actuates the trigger. The tacker does the rest.



At a recent forum and exhibit for architects and engineers, W. M. Woodworth, chief lighting engineer of Colonial Electric Products, Inc., gave an account of a fluorescent lamp developed by the company for home, commercial, and industrial use. It is known as the cold-cathode lamp. It is claimed that installa-

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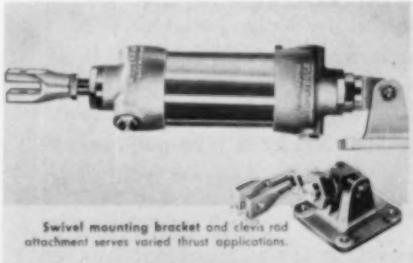
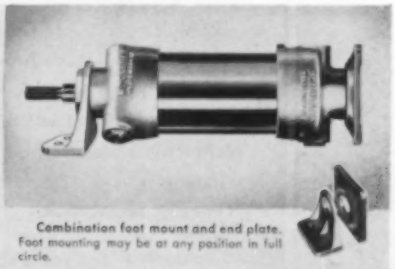
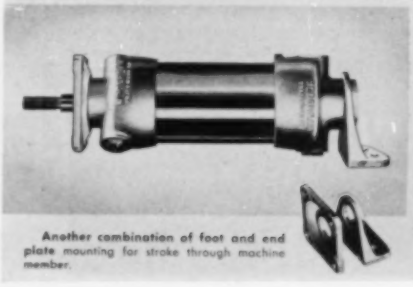
Threaded-head pneumatic cylinders of the Modernair cushion type are now available with an adjustable-cushion unit by which the speed of the cushion stroke may be varied. The unit may be attached to cylinders already in use or made for factory installation on new models. Features of the threaded-head series are heat-treated aluminum-alloy cylinder caps designed to take one or a combination of interchangeable mounting brackets, as the accompanying illustration shows; an end cap that permits making special cylinder assemblies —tandem or double-piston-rod; piping without elbows or "T" fittings because the caps, through the elimination of tie rods, rotate independently on the cylinder a full 360° without disturbing the end seals. Piston rods are of stainless steel, and the cylinder tube is of brass so that compressed air, water, or oil may serve as the operating medium. Experience with the cylinders indicates that they may be subjected to a temperature of 300°F. without injury to parts or the aircraft Type "O" ring packing used to prevent metal-to-metal contact at points of wear. Full-, semi-, as well as non-cushioned models are available.



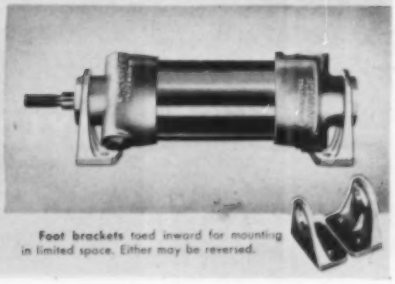
Swivel mounting bracket and clevis rod attachment serves varied thrust applications.



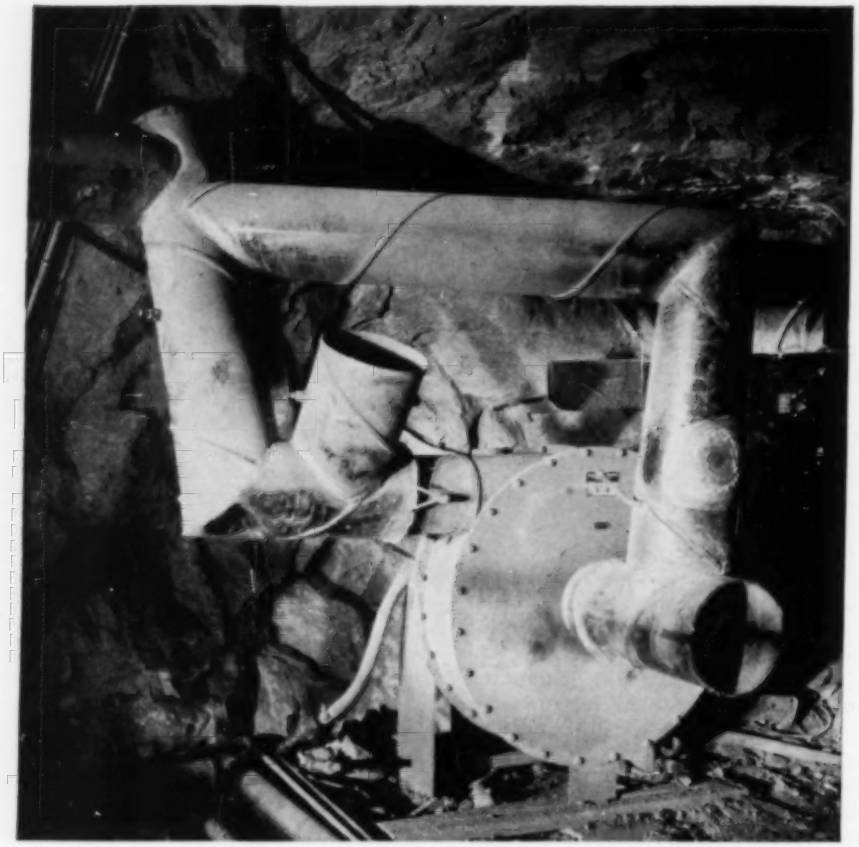
Combination foot mount and end plate. Foot mounting may be at any position in full circle.



Another combination of foot and end plate mounting for stroke through machine member.



Foot brackets toed inward for mounting in limited space. Either may be reversed.



You Can Depend on NAYLOR Pipe For Fresh Air Underground

For underground ventilating service, Naylor offers advantages found in no other light-weight pipe.

It is strong, tight, leakfree. The reinforcing truss created by the Lockseam Spiralweld assures additional collapse strength and holds accurate diameter and true cylindrical form so that ends always match correctly. Its light-weight makes it easy to handle and install. Also, the Naylor Wedge-Lock Coupling speeds installation. Joints can be made up with only one side of the pipe in the open, thus permitting the line to hug the wall wherever space is limited. From every standpoint, no other light-weight pipe can match Naylor in push-pull ventilating service. Sizes from 4" to 30" in diameter with all types of fabrication.

Naylor Pipe

NAYLOR PIPE COMPANY

1245 East 92nd Street, Chicago 19, Illinois

New York Office: 350 Madison Avenue, New York 17, N. Y.

tions of this type in the plant of a rubber company burned for 32,000 hours, or uninterruptedly for nearly twelve years based on a 10-hour working day and a 5-day week! In addition to long service life, the lamp is said to provide more than normal illumination with less glare and heat.

For the protection of trim, windows, etc., against paint overspray, the Detrex Corporation is offering a liquid masking compound that, diluted with water, can be applied by regular paint-spray equipment. It dries to form a soft coating that can be removed by washing.

An article in *Iron and Coal Trades Review*, a British publication, states that numerous compressed-air locomotives are still in service in Dutch coal mines. Originally adopted because they were safe in gassy workings, they have been retained because of the fact that they can be operated well-nigh continuously.

By fitting Schrader Pressure-Tel valve caps over standard tire valve caps of the same make, motorists and service attendants should have no trouble in keeping tires properly inflated. The number of pounds pressure a tire should carry for maximum driving comfort, safety, and mileage is permanently stamped on top of the cap.

Nails with two legs, one inside the other, and with a triangular loop on top have been put on the market by Elastic Stop Nut Corporation. They are 1¾ inches long and intended for such work as fastening wood shingles to gypsum sheathing. When driven, the last blow of the hammer flattens the top and clinches the bottom, locking the parts together. The nails are made of zinc-coated, low-carbon steel.

For use in mines, the Gates Rubber Company is producing hose that is bright yellow in color and therefore can be seen more readily than conventional hose in semidark openings. It is claimed to be more economical because it can be found quicker when needed, is not so likely to be left in the path of moving equipment and run over, and isn't often overlooked when equipment is removed from worked-out mine areas.

Many broken machine parts or tools that cannot be repaired by welding because the extreme heat would cause distortion or impair their cutting powers are now put back on the job by the use of silver brazing alloys. As explained by the Silver Users Association, the metal flows like water when melted and, when carefully applied, reaches all interstices of the irregular surfaces to be joined. The oven temperature at which the part is then baked is low enough to be harmless.

Industrial Literature

A book, entitled *Gas Tables*, has been written by Joseph H. Keenan and Joseph Kaye, both members of the engineering faculty of Massachusetts Institute of Technology, to supersede their earlier work, *Thermodynamic Properties of Air*. In the new volume the properties of air have been re-examined and recalculated, the properties of combustion products of hydrocarbons and their constituents added, and tables for the analysis of flow of compressible fluids greatly extended. Much of the material presented is of recent origin; all values of thermodynamic properties are based on data obtained from spectroscopic sources and published in 1945 by research workers of the National Bureau of Standards; and other valuable sections have been previously published only in the form of reports having limited circulation. The book is intended as an aid in designing gas turbines, in studying heat and power plants, and in calculating other engineering problems involving the use of air. Price $5, and obtainable from John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y.

Power Factor and What To Do About It is the title of a 20-page technical booklet issued by Electric Machinery Manufacturing Company, Minneapolis 13, Minn. Written for technical and operating men in industries using electrical machinery, it defines power factor; explains how a synchronous motor may be used to correct a low power factor; gives methods of calculating both power factor and power-factor correction for any given installation by means of tables and graphs; and lists economies to be gained through the maintenance of the correct power factor. Copies of Booklet No. 200-TEC-1077 will be sent without charge upon request.

Mills Alloys, Inc., 11320 South Alameda Street, Los Angeles, Calif., will send upon request a catalogue illustrating and describing the company's line of blasting nozzles fitted with tungsten-carbide liners to prevent wear. Also available is a series of booklets describing the use of the nozzles in sandblasting; foundry, heat-treating, and glass work; monument decorating; cleaning buildings; and maintenance work in railroad- and shipyards.

A 4-page technical report on fluorine corrosion is obtainable from The International Nickel Company, Inc., 67 Wall Street, New York, N. Y. The publication discusses high-temperature attack on metals by both fluorine and hydrogen fluoride and describes the varying degrees of resistance offered to these corrosive agents at different temperatures by nickel, Monel, and other materials. Included in the report are charts and a table giving rates of corrosive attack on the substances discussed. It was written by members of E. I. du Pont de Nemours & Company.

The 1948-49 edition of *Chemical Engineering Catalog* is now obtainable from Reinhold Publishing Corporation. Intended for use by operating officials charged with the selection and buying of goods for industries employing chemical processes, the Catalog provides a source of condensed and standardized data about raw materials, heavy and fine chemicals, machinery, laboratory supplies, etc. This thirty-third edition contains 1768 pages, has cross-referenced and classified indices, and includes a section cataloguing and describing a list of selected books on chemical and related subjects. Requests for copies should be made to the publishers at 330 West Forty-Second Street, New York 18, N. Y.

"VIC" TELLS HOW

ONLY A T-WRENCH IS NEEDED TO BUTTON UP 2-BOLT VICTAULIC COUPLINGS!

ANY PIPING SYSTEM can be buttoned up by a few fast turns of a standard T-wrench . . . when you use Victaulic Couplings with their famous 2-bolt simplicity.

YOU SAVE time and cut labor costs, too . . . because Victaulic Couplings are so fast and easy to install that no specially trained or skilled labor is needed.

ADD FULL-FLOW Victaulic Elbows, Tees, and other Fittings and you'll not only increase the output of your pipeline . . . you'll also lower your pumping costs!

USE THE NEW "Vic-Groover" and find out how it grooves pipe ends twice as fast . . . with half the effort of ordinary pipe threaders!

WRITE TODAY for these two: Victaulic Catalog and Engineering Manual No. 44. "Vic-Groover" Catalog No. VG-47.

Sizes—¾" through 60"

FOR FULL ECONOMY...MAKE YOUR PIPING SYSTEM ALL VICTAULIC!

SELF-ALIGNING PIPE COUPLINGS
VICTAULIC
EFFICIENT FULL-FLOW FITTINGS

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Victaulic Co. of Can. Ltd. 200 Bay St., Toronto 1

For Export outside U. S. and Canada: PIPECO Couplings and Fittings • Pipe Couplings, Inc., 30 Rockefeller Plaza, New York 20, N. Y.

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REPAIRED

Punch Press frame repair-welded with 52 lb. of 3/8" Tobin Bronze by the Sutton-Garten Company, Indianapolis, Ind. Job took one day for preparation and one day for welding.

RECONDITIONED

This group of worn and broken gears from wire braiding machines was quickly and economically reconditioned with Tobin Bronze Welding Rod.

...by TOBIN BRONZE WELDING

Almost any piece of equipment made of cast iron, malleable iron, steel or copper alloys can be quickly and economically repaired by oxy-acetylene welding with Tobin* Bronze.

Because of the low temperature used when welding with bronze, no serious stresses are set up, there is less chance of warping or cracking and parts can often be welded without dismantling equipment.

For years, this method of bronze welding has been used for reclaiming broken, fractured or worn equipment, or for building up bearing surfaces—at a fraction of the cost of replacement parts.

Write for Publication B-13, containing detailed information on Anaconda Welding Rods, including Tobin Bronze and "997" (Low Fuming). 47171A-Rev.

*Reg. U. S. Pat. Off.

ANACONDA

Anaconda

WELDING RODS

THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

In Canada: ANACONDA AMERICAN BRASS LTD.
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50% weight reduction in hose line speeds air tool operations

New hose by B. F. Goodrich halves weight, adds flexibility and strength

NEW B. F. Goodrich Highflex hose for small air tools is twice as light yet stronger than ordinary air hose. 50% weight is saved by use of a thinner wall which actually has *higher* burst strength than heavy old-type hose of equal capacity. Here's a hose that's light and flexible as a lamp cord.

Saves 50% weight—Highflex weighs 50% less than ordinary air hose. A 100-ft. length of Highflex hose weighs 8.8 lbs. in ¼" size; ordinary hose of the same size weighs 20 lbs. And substantially similar savings are made in all sizes of Highflex.

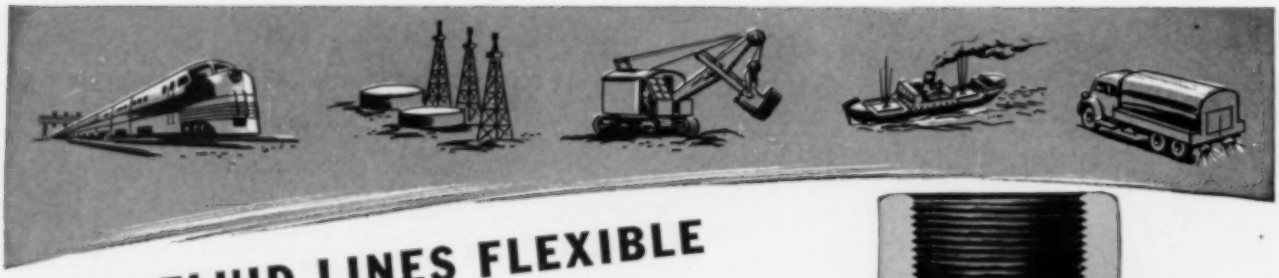
Easier to use—The greater flexibility of Highflex hose makes it easier to handle, to use in close quarters, to keep kinkless. Lightweight line and better handling qualities reduce fatigue of the operator, make air tool operations faster and more economical.

Strength under pressure—Highflex has a working pressure of 250 lbs.—a high margin of safety for any small air tool. Braid placed at an angle that insures low expansion under pressure.

Completely oilproof—Highflex hose is completely oilproof, on the inside and outside. Lubricating oils won't cause Highflex to swell and flake, cutting air volume or jamming the tool.

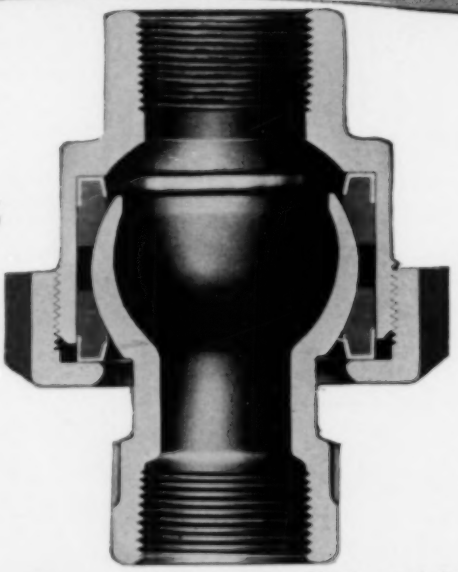
Other Highflex features—Cover resists sun checking, tearing and snagging, and abrasive wear. Smaller bulk takes up less storage space. Highflex comes in attractive red color of high visibility. Ask your distributor for prices and full details, or write: *The B. F. Goodrich Company, Industrial Products Division, Akron, Ohio.*

B.F. Goodrich
RUBBER FOR INDUSTRY



KEEP FLUID LINES FLEXIBLE

WITH BARCO JOINTS



Operators of air, steam or hydraulic equipment find it necessary to have flexibility in their pipe lines to move the equipment while operating, or to take care of vibration, and prevent pipe breakage. There is no better way to accomplish this purpose than by the use of BARCO FLEXIBLE JOINTS, in connection with steel pipe. This combination will stand temperature, pressure, and abuse, which no other form of container will stand.

Millions of BARCO Joints are in service all over the world, and they will give you just as good service as they have given others. Ask for technical information on your specific problems, together with prices and recommendations. Write Barco Mfg. Co., 1837 Winnemac Ave., Chicago 40, Ill. In Canada: The Holden Co., Ltd., Montreal, Canada.

BARCO *FLEXIBLE JOINTS*

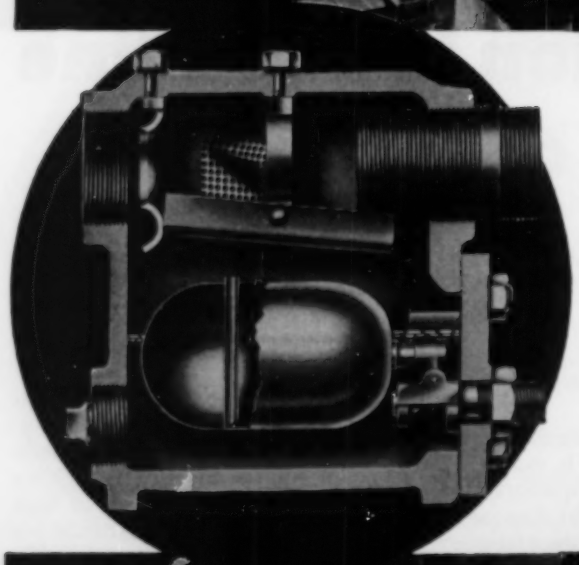
FREE ENTERPRISE—THE CORNERSTONE OF AMERICAN PROSPERITY

"MOVE IN EVERY DIRECTION"

Not just a swivel joint ...but a combination of a swivel and ball joint with rotary motion and responsive movement through every angle.

DRI AIR MAY BE INSTALLED BY SUSPENDING IT FROM THE PIPING WITHOUT ANY OTHER SUPPORT.

INCREASED PNEUMATIC EFFICIENCY WITH THIS AUTOMATIC SEPARATOR



PROTECT EQUIPMENT WITH

DRIAIR

SEPARATES • COLLECTS • DELIVERS

• DriAir separates and automatically ejects the condensed water and oil from compressed air lines, collects pipe scale and rust, delivers clean dry air to tools and other pneumatic equipment. This promotes better lubrication, reduces wear, increases life of tools and produces greater output. All internal parts are made of bronze or copper—resistant to corrosion and practically permanent.

A TYPICAL INSTALLATION SHOWING DRI AIR STANDING ON A CONCRETE FLOOR NEXT TO THE WALL.

WRITE FOR BULLETIN DA WHICH FULLY DESCRIBES THE CONSTRUCTION AND OPERATION OF THE DRIAIR.

NEW JERSEY METER CO.

"SPECIALISTS IN COMPRESSED AIR DEVICES"

PLAINFIELD, NEW JERSEY

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"Certified" Service

A BREAKDOWN on this 39-year-old Allis-Chalmers fan motor crippled operations at the plant of an important midwest electric utility. Immediate repair was vital. The Chief Engineer called the nearest Allis-Chalmers Certified Service shop. They picked up the rotor and returned it ready for service in less than twenty-four hours.

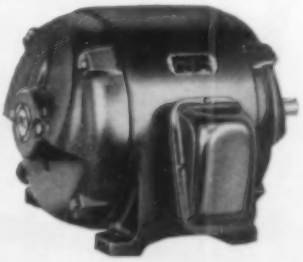
This is the kind of emergency cooperation you can expect from every Allis-Chalmers Certified Service shop. On everyday repairs and maintenance too, your Allis-Chalmers Certified Service shop will give you prompt service on Allis-Chalmers motors, pumps and transformers, using factory approved methods and parts. Every Allis-Chalmers Certified Service shop has been selected for skilled, personal, careful workmanship, adequate equipment and *service mindedness.*

HOW TO FIND NEAREST SERVICE SHOP

Allis-Chalmers Certified Service shops are located in major industrial centers throughout the country. New shops are being appointed continuously and most smaller centers will soon be covered. To find the shop nearest you, call your closest Allis-Chalmers District Office. A 2543

MOTOR DELIVERIES GREATLY IMPROVED

Many types of Allis-Chalmers Motors are now in stock! Many other types are available on short delivery! For motors from 1 to 200 HP, check your nearest Allis-Chalmers Authorized Dealer. For motors larger than 200 HP, check with the nearest District Office. You may be able to get what you need sooner than you think.



ALLIS-CHALMERS, 1000A SO. 70 ST.
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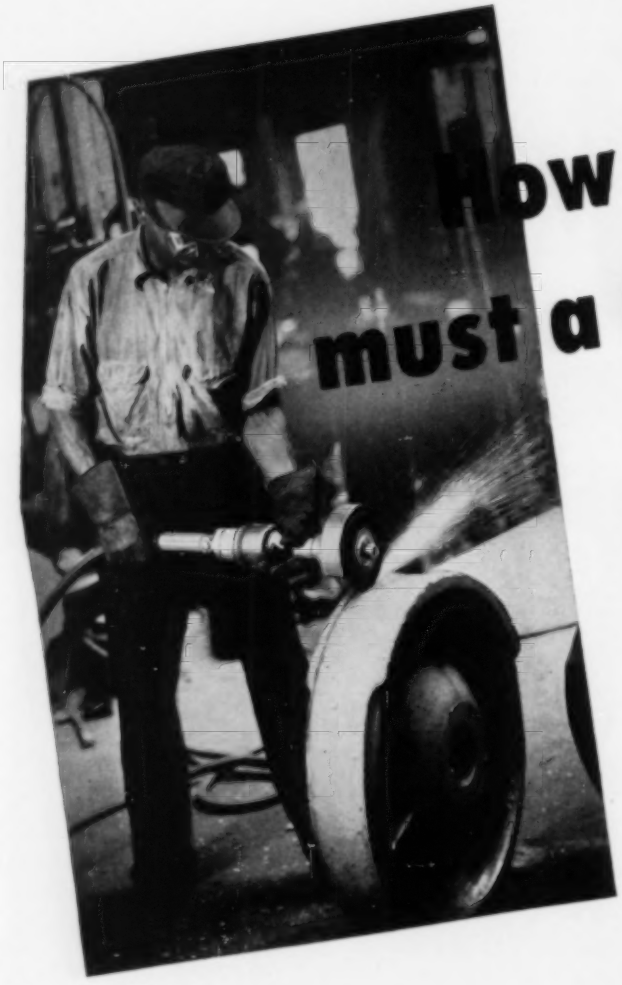
ALLIS-CHALMERS

Pioneers in Power and Electrical Equipment from Generation through Utilization



How TOUGH must a GRINDER be?

TOUGH enough:

1. To remove hard metal.
2. To operate continually at maximum grinding efficiency.
3. To withstand rough handling.
4. To keep out all dirt.
5. To never burn out.

These tough, hard to meet grinding requirements are met by Ingersoll-Rand Air Grinders with speeds as high as 20,000 rpm . . . with a sensitive governor or speed regulator that permits operation of the grinder at its most efficient speed, and also prevents overspeeding . . . with rotor bearings sealed against the entrance of dirt . . . with cool running, multi-vane motors that will never burn out.

Light-weight I-R Air Grinders have balance for smooth, vibrationless operation and an automatic oiler for continuous lubrication of the entire motor assembly.

Take advantage now of Ingersoll-Rand Air Grinders. Just call our nearest branch office . . . or write for our Air Tools Bulletin.

AIR TOOLS
COMPRESSORS
CONDENSERS
TURBO-BLOWERS
CENTRIFUGAL PUMPS
OIL & GAS ENGINES

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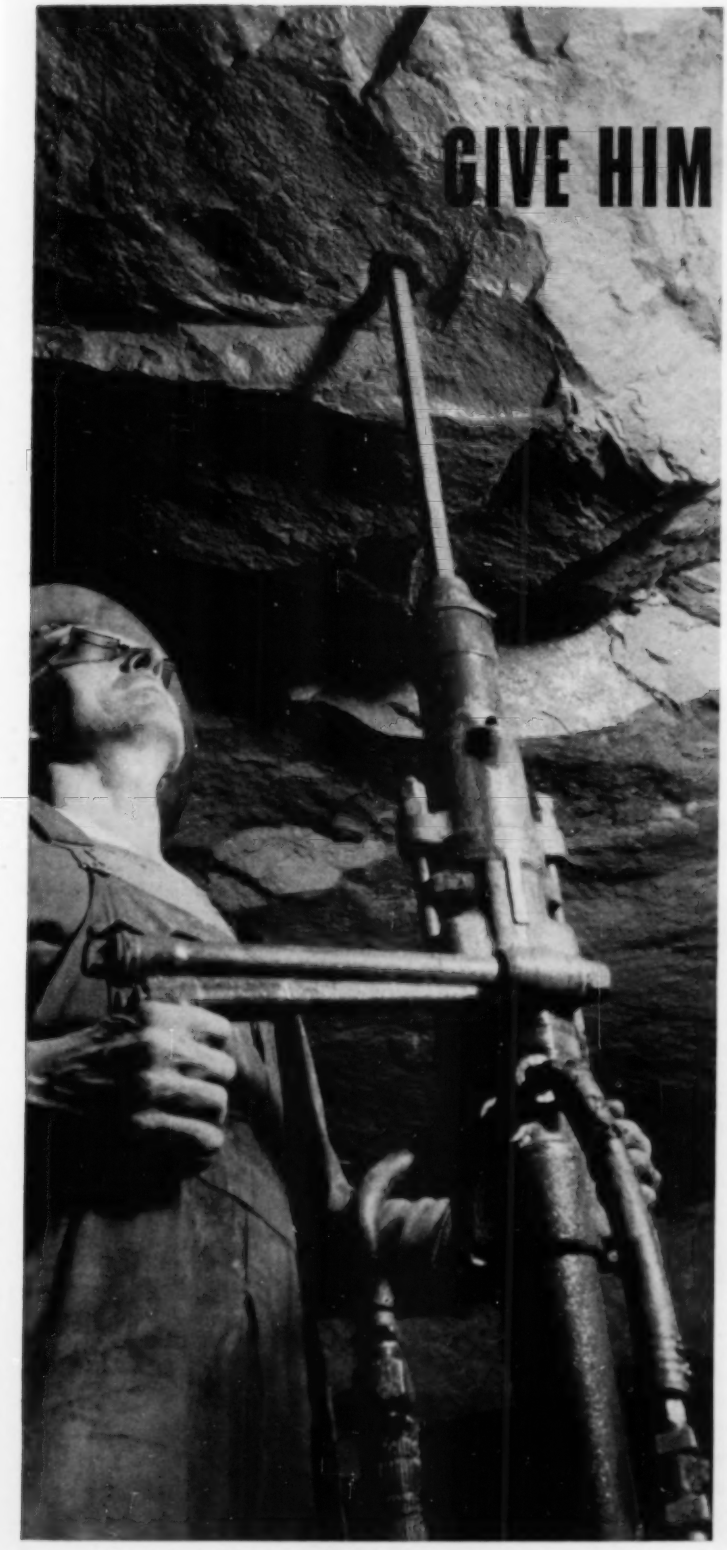

GIVE HIM GOOD DRILL STEEL

Make sure you're sending the best possible drill steel underground. Specify Bethlehem Hollow, for here's fine-quality steel that's been thoroughly proved in every mining area. And be sure that your steel is accurately forged and carefully heat-treated. Do this and you'll get extra footage, lower costs.

We have no spectacular claims to make about Bethlehem Hollow. It's a one-purpose steel that's been carefully made, rigidly inspected. You'll find it's easy to forge. And it's not a fussy steel to heat-treat, for it has a wide quenching range. It's tough, fatigue-resisting steel—ready to take hundreds of sledge-hammer blows each minute from your modern, faster rock drills.

Whether you use forged or detachable bits, you'll like the way Bethlehem Hollow stays on the job longer. Available for prompt shipment.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by
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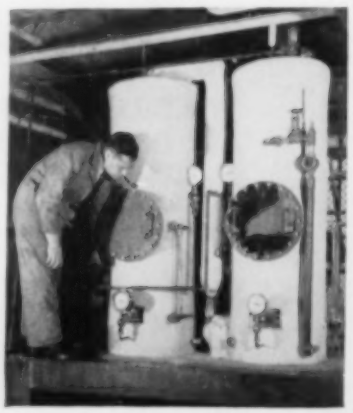
★ BETHLEHEM STEEL ★

BETHLEHEM HOLLOW DRILL STEEL

HAVE YOU A FRESH WATER PROBLEM?

Any evaporator can produce fresh water, but what you want is efficiency. Scaling, the big headache, is reduced to a minimum in Maxim Evaporators because of their very high circulation rate. When descaling is necessary a unique design feature allows quick and easy descaling, cutting down time by hours.

Maxim Evaporators are extremely compact . . . automatic in operation, and produce fresh water to a purity of 2/10 grains of solid per gallon, or 3½ parts per million. They are available in single or double effect. The two evaporators shown produced on test 2500 gals. per day and higher capacities are possible. Investigate these very efficient evaporator units.

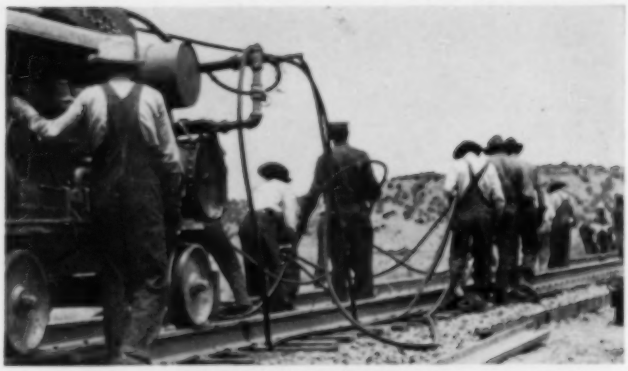


SEND FOR BULLETIN

Eight pages of information, detailed drawings, diagrammatic hook-ups, single and double effect.

THE MAXIM SILENCER COMPANY
61 HOMESTEAD AVE. HARTFORD 1, CONNECTICUT

BE SURE IT'S A MAXIM



A *Tough* HOSE FOR *Rough* SERVICE!

The Goodall "Standard of Quality" hose you can rely on for safe, low-cost service in all heavy-duty air tool applications. Extra strong wrapped duck construction. Wear-resistant *red* cover. Sizes ½" to 1¼", in lengths up to 50 feet.

"SUBWAY" *Heavy Duty* AIR HOSE

Contact Our Nearest Branch for Complete Information.

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Branches: Philadelphia • New York • Boston • Pittsburgh • Chicago • St. Paul • Los Angeles
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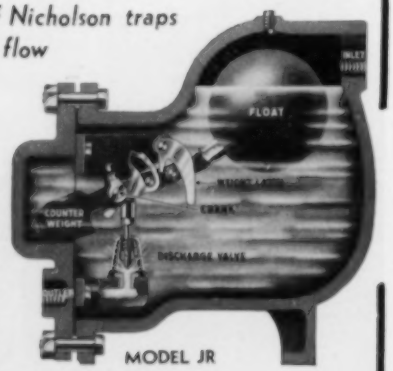
DO SLUGS Slow Your Air?

Large Capacity of Nicholson traps Prevents Sluggish flow



MODEL JR

Wherever maintenance of maximum air flow is a problem due to slugs of water, oil, or dirt in volume, Nicholson air traps are especially specified. Their extra large capacity assures positive drainage of intercoolers, aftercoolers, receivers, etc.

Leak-Proof Valve Prevents Medium Loss

Other features positive fluid seal over discharge valve prevents loss of medium; non-wire drawing; working parts of stainless steel prevent corrosion trouble; rugged, for unavoidable abuse. 3 types for pressures to 1500 lbs. CATALOG 448.

W. H. NICHOLSON & CO. 180 OREGON STREET WILKES-BARRE, PA.
Valves ★ Traps ★ Steam Specialties

Send FOR THIS NEW CATALOG

Square D offers a wide range of pressure, float and temperature switches for practically all sizes of water pumps, condensate pumps, vacuum pumps, air compressors, machine tools and other machinery involving pneumatic or hydraulic systems. Send for your free copy of Pump Control Catalog, with illustrations and specifications.

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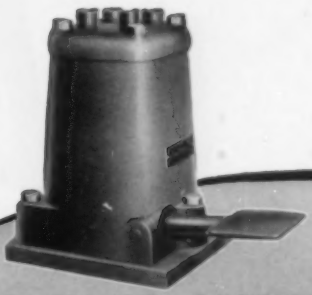


Quick-As-Wink FOOT OPERATED Control Valves

for better, faster production

● Ideally used with shears, presses, forging machines and other machinery of all kinds because the operator has both hands free to handle the work. Features all service-proved Quick-As-Wink design and construction advantages. No metal-to-metal seating. No leakage or bleeding. ⅜"; ½"; ¾"; 1"; 1¼"; and 1½" sizes. 3-way and 4-way neutral position or regular actions.

Send for a catalog today—and get full details about the complete line.

Manufactured by **C. B. HUNT & SON, INC.,** *Salem, Ohio*

ENGINEERING AND SALES REPRESENTATIVES IN THE PRINCIPAL CITIES

"there's PROTECTION in fog"

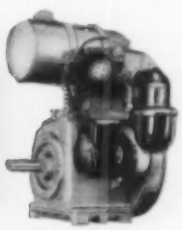
NORGREN LUBRICATORS inject oil automatically into the air stream of pneumatic tools and cylinders, creating an air-borne fog that deposits a film of lubricant on every moving part.

Certain protection against excess wear, rust and corrosion.

Write C. A. Norgren Company, 222 Santa Fe Drive, Denver 9, Colorado.

Norgren

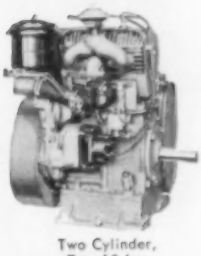
When You Specify WISCONSIN Air-Cooled ENGINES You Get...



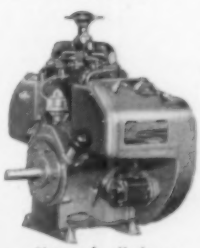
Single Cylinder, 2 to 9 hp.

- Heavy-Duty, long term service . . .
- Weather-proof, automatic cooling . . .
- Foolproof lubrication . . .
- Quick, sure-fire starting in any climate, at any season . . .
- Full load power delivery on a continuous service basis if that's what the job calls for . . .
- Light weight and extreme compactness . . .
- Broad-range power adaptability . . .
- Top economy and operating efficiency . . .
- Ready availability of parts and service if and when needed . . .
- Popular and enthusiastic recognition and endorsement in all fields of engine power service . . .
- Your choice of power to fit the machine and the job in 4-cycle single cylinder, 2-cylinder and 4-cylinder engines, in a power range from 2 to 30 hp.

Let us supply you with full details, including engineering data applying to your specific power problems.



Two Cylinder, 7 to 13 hp.



V-type 4-cylinder, 15 to 30 hp.

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 14, WISCONSIN

Announcing

NEMA Sizes 0, 1, 2, 3
for a-c motors
up to 50 hp

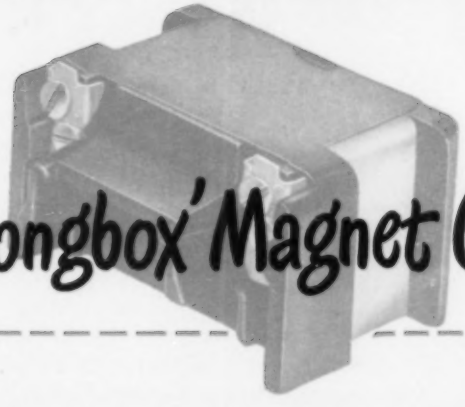
GENERAL ELECTRIC

a complete NEW line

MOTOR STARTERS

with the

'Strongbox' Magnet Coil



all new all the way thru

Here it is—a completely new line of G-E motor starters—full-voltage starters made for extra-long life, faster installation. Designed for easy maintenance, but built so you can forget them.

NEMA Sizes 0, 1, 2, and 3—each size new all the way through. Everything's new—contacts, arc hood, magnet, armature, and the tough Strongbox magnet coil. Get your first G-E starter and compare!

SO NEW
SO DIFFERENT
YOU CAN'T AFFORD TO WAIT
ORDER TODAY!

General Electric Company
Apparatus Dept.
Sec. J676-277
Schenectady 5, N. Y.

Please send me your bulletins describing the new a-c motor starters:

GEA-5153 (CR7006 A-c Magnetic Starter)_____

GEA-5156 (CR7008 A-c Combination Starter)_____

Name_____

Company_____

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WITH HANSEN COUPLINGS

QUICK-CONNECTIVE COUPLINGS FOR

- AIR
- ACETYLENE
- OIL
- GASES
- GREASES
- STEAM
- OXYGEN
- HYDRAULIC

CONNECTION TAKES ONLY A SECOND

Threading fluid line couplings on and off to connect or disconnect is an unnecessary waste of time. Any line can be quickly and easily connected by using a Hansen Coupling. And, in addition, couplings have shut-off features that prevent loss of the liquid or gas in the line.

When you want to connect a Hansen Coupling, it is merely necessary to push the plug into place, where it locks securely. The valve opens, and flow starts instantly. The same operation disconnects—move the sleeve, and the plug pops out. Flow is shut off automatically.

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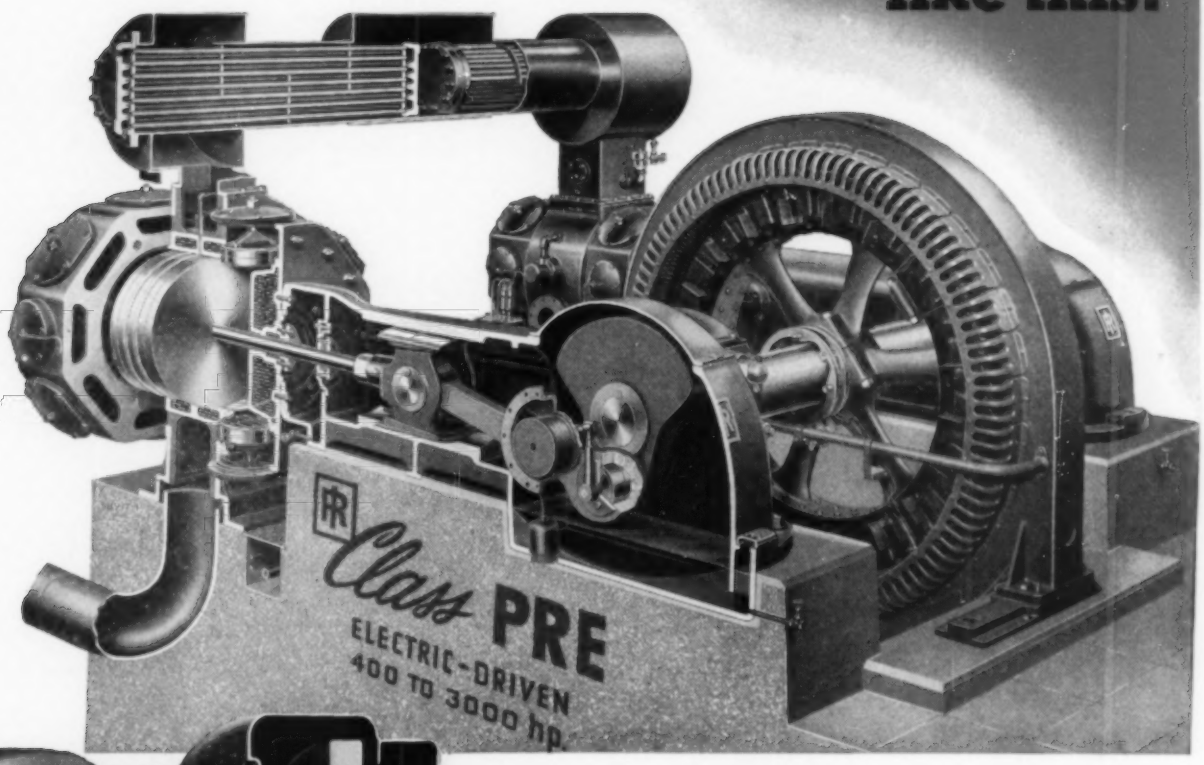

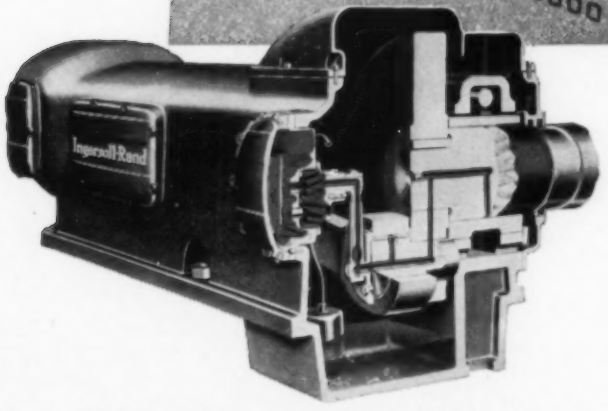

Oil-pump drive and distribution system (patented) are combined to feed filtered oil directly to the crankpin, main bearings and crosshead.

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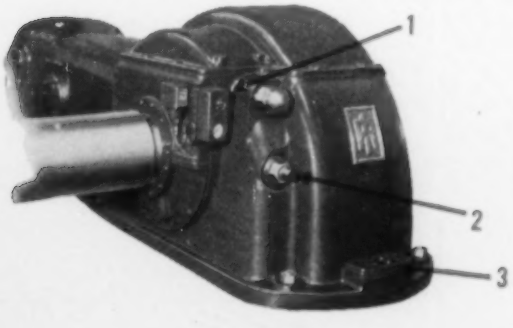

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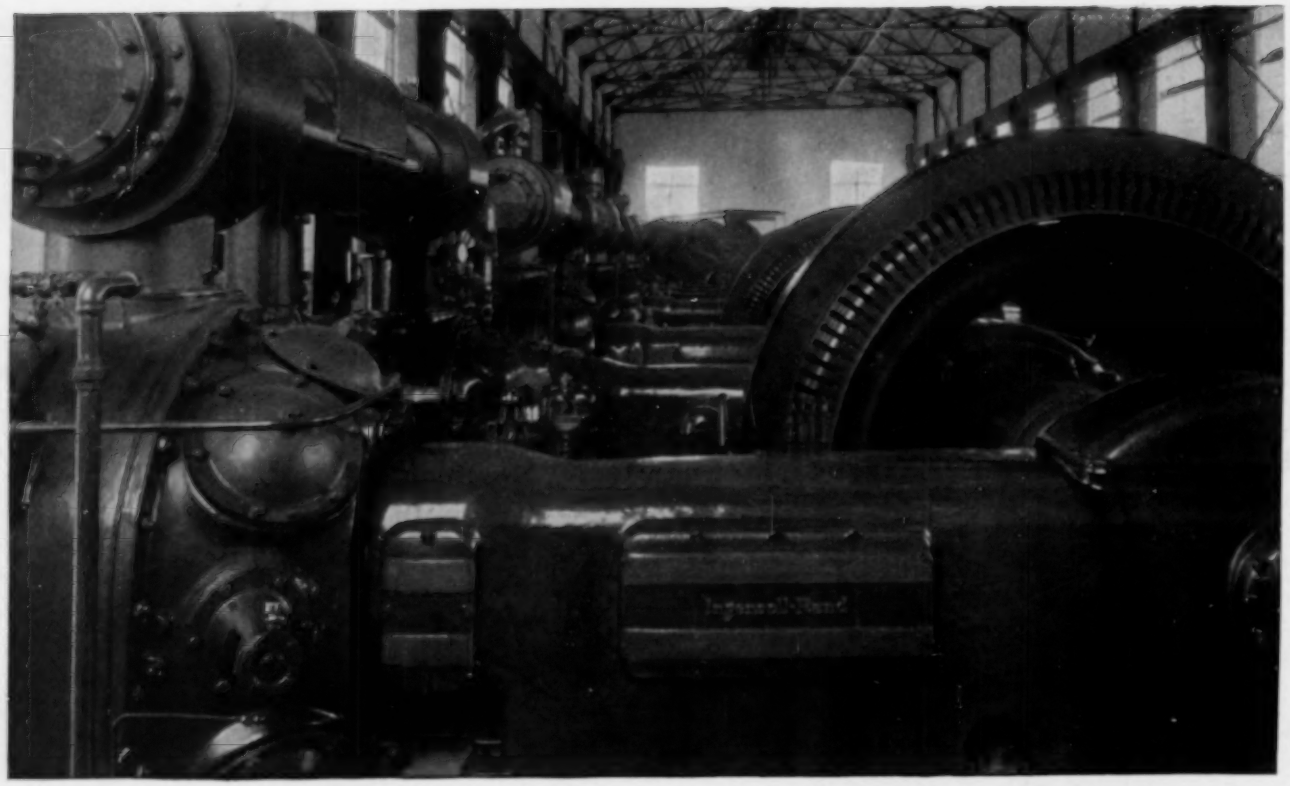

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